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AEROSPACE MEDICINE

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The Passive Dynamic Mechanical Property
of the Human Thorax-Abdomen System
and of the Whole Body System

Rolf R. Coermann, Dr. Ing., et al.

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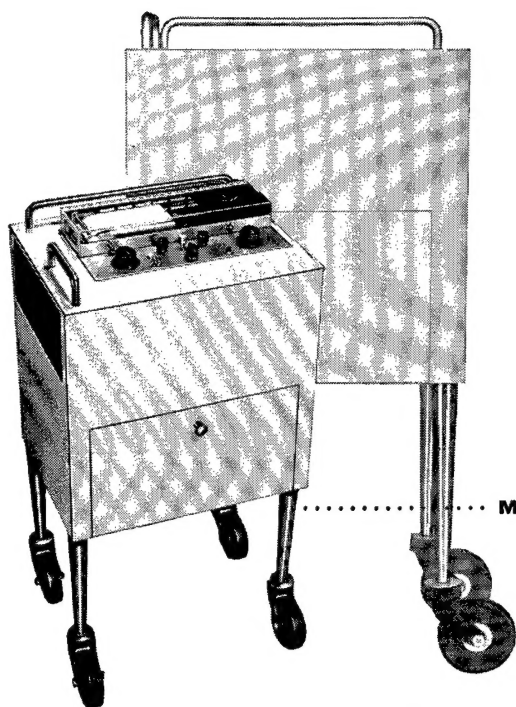
- ♦ Hypoglycemia
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- ♦ Properties of the Thorax-Abdomen

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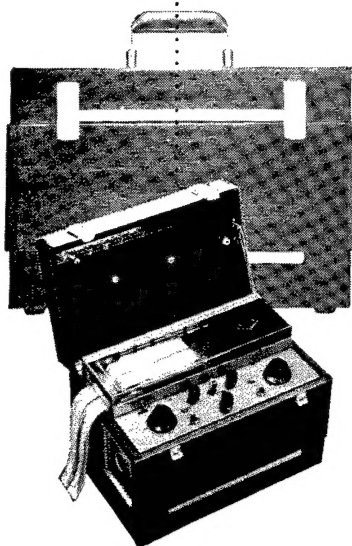


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The Passive Dynamic Mechanical Properties of the Human Thorax-Abdomen System and of the Whole Body System

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ALBERT L. WITTWER, B.S., HENNING E. VON GIERKE, DR. ING.

WHEN THE human body is exposed to steady state or impulsive mechanical forces, the investigation of the dynamic mechanical response of the body system is the first step toward the explanation of the physiologic or pathologic effects generated by this environment. The understanding of the body as a mechanical transmission system will allow us to calculate the forces and resulting displacements between parts of the body, between organs, the deformation of organs and the mechanical stimuli acting at the various neural receivers. Only such detailed study of the physical response of the body will lead to a quantitative understanding of the observed biological phenomena. It should be the goal of all such investigations to describe the body system as completely

and generally as possible so that the results are valid not only for the specific stimulus for which the observations were made but can also be used to calculate the response to different types of mechanical stimuli. For example, it is possible to calculate the response to impact forces or rapid decelerations from the steady state response of the body to sinusoidal forces as has been attempted for the ejection seat problem.⁴ It should be possible, once the physical parameters of the system are known, to calculate its response to forces acting on body parts which are different from those parts the forces were acting on when the system was initially measured. It is obvious that, due to the complexity of the body structure, our descriptions of the body's dynamic mechanical properties are approximations. It is known that tissue responses become nonlinear in most force ranges of biological interest and that the assumption that the body is a passive system is a convenient but

From the Bio-Acoustics Branch, Aerospace Medical Laboratory, Wright-Patterson AFB, Ohio.

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not too valid idealization. However, such refinements and complications can be introduced later when the basic linear passive characteristics of the

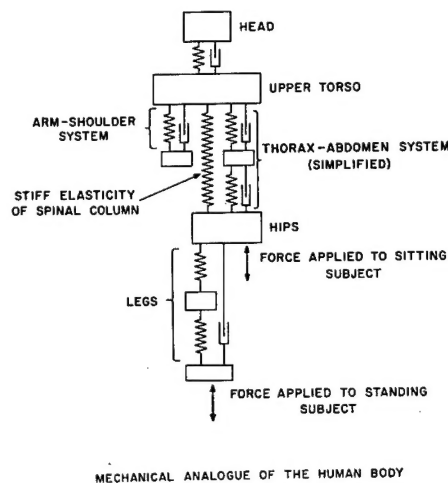


Fig. 1. Simplified mechanical circuit for the human body exposed to longitudinal vibrations of very low frequencies. The points of force application are indicated for a man sitting and standing on a vibrating platform. The system determining the impedance of the whole body system (mass of upper torso vibrating in connection with the elasticity of the pelvis and spine) and the thorax-abdomen system are shown in the analogue.

system are understood; for most applications, they will always be a good first approximation.

Impedance Measurements on the Whole Body System.—For forces, which have most components of their frequency spectrum below approximately 100 cps., it is usually possible to describe the important features of the response of the human body by simple mechanical circuits using lumped parameter systems. For these considerations, the mass of the tissue responding by relative displacement to

an applied force is separated from the purely elastic and energy absorbing structures. Figure 1 illustrates such a circuit for the standing man. The individual parameters of this system can be only roughly estimated from measurements of the transmission factors as a function of frequency; for example the resonance curve, which was obtained for the motions of the head relative to the shoulder, peaks between 20 and 30 cps.² At this resonance frequency, the head amplitude exceeds the shoulder amplitude by approximately a factor of three. If the resonance frequency and amplification factor are known and the mass of the head is estimated, specific quantities can be assigned to the spring and frictional resistance of the head subsystem. Similar estimates can be made for other subsystems of the body, but it is obvious that the head is the simplest example. For other body parts, for instance, the abdominal viscera or the thighs, it is first, not easy to decide which tissue parts constitute the effective mass of the system, and secondly it is difficult to make exact measurements of the vibration amplitude of these parts which do not move as a unit mass as does the rigid head. The measurement of the mechanical impedance, which is a more informative parameter of the mechanical system or subsystem, can be of extreme value here in obtaining insight into the complexity of the total mechanical system and to assign absolute quantities to the parameters. The mechanical impedance is, in analogy to the electrical impedance, defined as the complex ratio of the applied or transmitted force to the velocity resulting at the point of force

transmission. The measurement of impedances involves, therefore, the measurement of force and velocity and of the phase angle between these quanti-

ties. The measurement of impedances involves, therefore, the measurement of force and velocity and of the phase angle between these quanti-

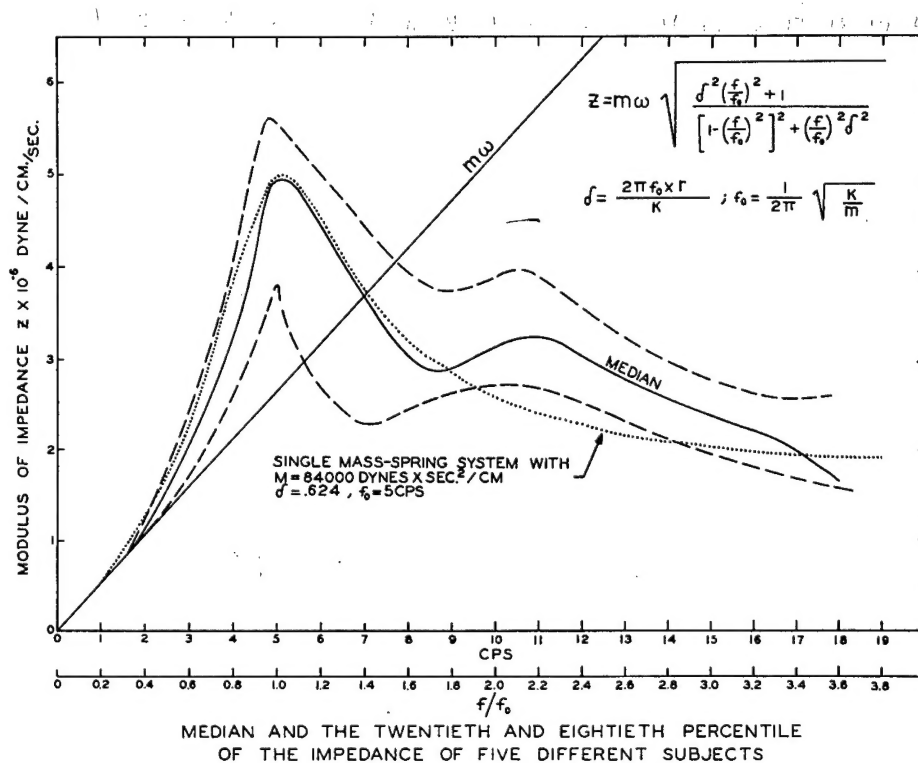


Fig. 2. Median and twentieth and eightieth percentile of the mechanical impedance measured on five sitting subjects (longitudinal vibrations). The impedance of a simple damped mass-spring system with the same effective mass m and damping δ is indicated by the dotted line. (K =spring constant, r =resistance, f =frequency, f_0 =resonant frequency, $\omega=2\pi f$.)

ties. Thus, it is not possible to make impedance determinations on coupling points between subsystems in the body because measurements of the transmitted force are not possible at these points. However, wherever a subsystem is accessible from the outside its impedance can be determined. The impedance functions allow the derivation of more quantitative information on the mechanical system. It depends on

in contact with this point or also the impedance of neighboring circuits.

Knowledge of the impedance allows calculation of the absolute mechanical energy transmitted to the system, a quantity of extreme interest for mechanical-pathological as well as physiological effects. An example of such impedance functions for the frequency range 1 to 20 cps. is given in Figure 2 for a sitting human subject. Up to ap-

BODY DYNAMIC MECHANICAL PROPERTIES—COERMANN ET AL

proximately 2 cps., the impedance is identical with a pure mass reactance, that is, the body moves as a unit mass. At approximately 5 and 11 cps., the impedance by the impedance of a simple damped mass-spring system and to assign definite values to the effective mass, spring and damping. The same

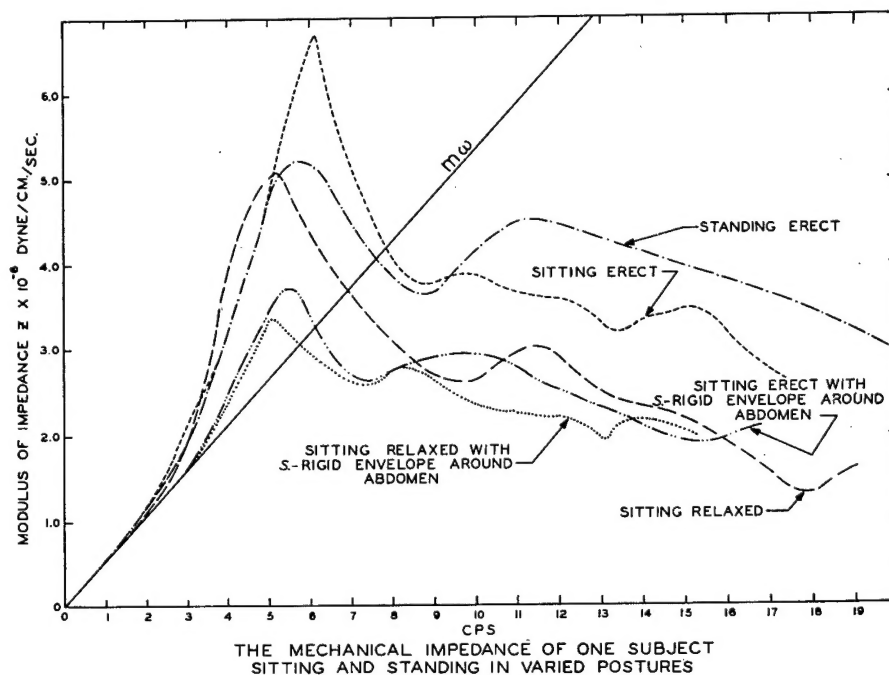


Fig. 3. Influence of body posture and semi-rigid envelope around abdomen (tight fitting non-elastic nylon girdle reinforced with stays) on the mechanical impedance of a sitting human subject (longitudinal vibrations). Since the impedance reflects the mechanical energy transmitted to the body, its use for the quantitative evaluation with respect to vibration transmission for different body postures, seats, harnesses, etc., is proposed.

curve exhibits resonance peaks. At these frequencies, maximum energy is transferred from the seat to the body. The peak of 5 cps. is caused by resonant motions of the mass of the upper torso in connection with the bending elasticity of the pelvis and spine; the peak at 11 cps. is probably attributable to another elasticity of the pelvis. As the dotted curve in Figure 2 indicates, it is possible to approximate, in the range of resonance, the measured im-

pedance values can be used to calculate the body response to impact forces transmitted by the seat; as found, for example, in rapid deceleration or seat ejection. Transient oscillations, depending on the time history of the force, with the same natural frequencies will show up in the impact response. Differences in body posture, in the support or restraint of the body, and in seat and seat-cushion properties are all reflected in the respective im-

pedances which permit these factors to be quantitated with respect to energy transfer and impact response. Examples of the variation of impedance with posture are given in Figure 3.

The Thorax-Abdomen System.—The impedances of subjects in the sitting, standing or lying positions have recently been measured for a larger group of subjects¹ and are important as measures for the energy transmitted to the body. To determine the effect of this energy within the body in response to impact, as well as steady state forces, another mechanical circuit is equally important. It is the system designated as abdominal viscera in Figure 1, which shall be called the thorax-abdomen system in the following discussion. It is only loosely coupled to the skeleton and the masses and energies involved in its vibrations are relatively small compared to the ones involved in the excitation of the whole body. However, this system has been found to be of extreme if not vital importance with respect to the ability of the human body to tolerate physiologically impact and vibration exposure. When the accelerative forces are increased, the relative displacements of this system with respect to the skeleton will cause the elastic limits of this tissue to be exceeded before those of other tissue are exceeded. Abdominal or lung injury results are observed on humans and animals when they are exposed to excessive impact or steady state acceleration loads.^{5,6} Roman made the first quantitative investigation of this abdominal resonance by exposing mice to sinusoidal vibrations and by correlating the frequency of

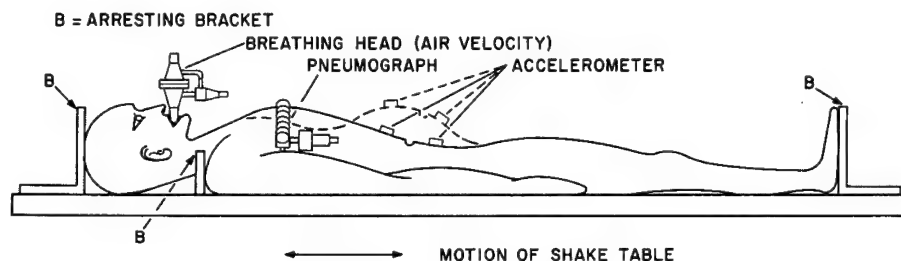
maximum biological effect between 20 and 25 cps. with the resonance of the abdominal system.⁶ It was obvious that a similar resonance must occur on human subjects; however, due to the larger dimensions involved, this resonance had to be expected at much lower frequencies than in the range observed for the mouse. The remainder of this paper is devoted to observations on this system and to the correlation and discussion of the results obtained.

The abdominal viscera has a high mobility due to the very low stiffness of the diaphragm and abdominal wall and of the air volume of the lungs and chest walls behind it. Therefore, under the influence of longitudinal as well as transverse vibrations of the torso, the abdominal mass vibrates in and out of the thoracic cage. During the phase of the cycle, when the abdominal contents swing caudad, the abdominal wall is stretched outward and the abdomen appears larger in volume. At the same time, the downward deflection of the diaphragm causes a decrease of the chest circumference. At the other end of the cycle, the abdominal wall is pressed inward, the diaphragm upward and the chest wall is expanded. These vibrations of diaphragm and chest wall result in compression of the lungs and cause forced air oscillations through the trachea and mouth. The experimental method was therefore designed to measure the response of the complete system.

Method of Investigation of the Thorax-Abdomen System.—The subject was placed in the supine position on a shake table and was vibrated with sinusoidal motions longitudinally (Fig.

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- 4). Longitudinal vibrations of the skeleton due to skin and muscle elasticity were suppressed as far as possible by clamping the subject between
- of these different response curves, which describe all the same phenomenon and are usually all called "resonances," occur at different frequencies.



DETERMINATION OF THE DYNAMIC RESPONSE OF THE HUMAN THORAX-ABDOMEN SYSTEM

Fig. 4. Instrumentation for determining the dynamic response of the human thorax-abdomen system. The brackets B couple the skeleton rigidly to the table for the frequency range under consideration.

heavy metal brackets at the feet, shoulders and head. Longitudinal impedance measurements in this position showed that there was an absolutely rigid connection between table and skeleton over the frequency range of interest here. Vertical accelerations of different points of the abdominal wall were measured with accelerometers taped to the skin by adhesive tape. Changes in chest circumference were measured with a pneumograph and the alternating air flow through the mouth was measured with a breathing head. Abdominal motion, chest motion and air flow through the mouth were evaluated for the filtered fundamental frequency of the exciting table vibration. In comparing the response curve of the different quantities, it is important to state clearly whether one talks about the response curve of acceleration, velocity or displacement. The maxima

Statements in the literature on resonant frequencies of body systems are sometimes confusing because this differentiation is not taken into account. In order to gain further insight into the system, attempts were made (1) to stiffen the elasticity of the suspension of the viscera mass, that is, the elasticity of the abdominal wall and diaphragm and (2) to stiffen the elasticity of the chest wall. Mobility was restricted in both cases by tightly-adjusted, strong nylon restraints compressing either abdomen or chest. Details on the measurements will be published elsewhere. Typical results obtained on one subject, which are representative of the data to be published on a larger group, will be discussed here.

Response of the Thorax-Abdomen System.—Typical response curves for

BODY DYNAMIC MECHANICAL PROPERTIES—COERMANN ET AL

the vertical vibration amplitude of the abdominal wall, the circumference changes of the chest and the oscillating air volume forced through the open

that the resonance determined by this method agrees fairly well with the resonance estimated by the x-ray method. In the latter method, the static dis-

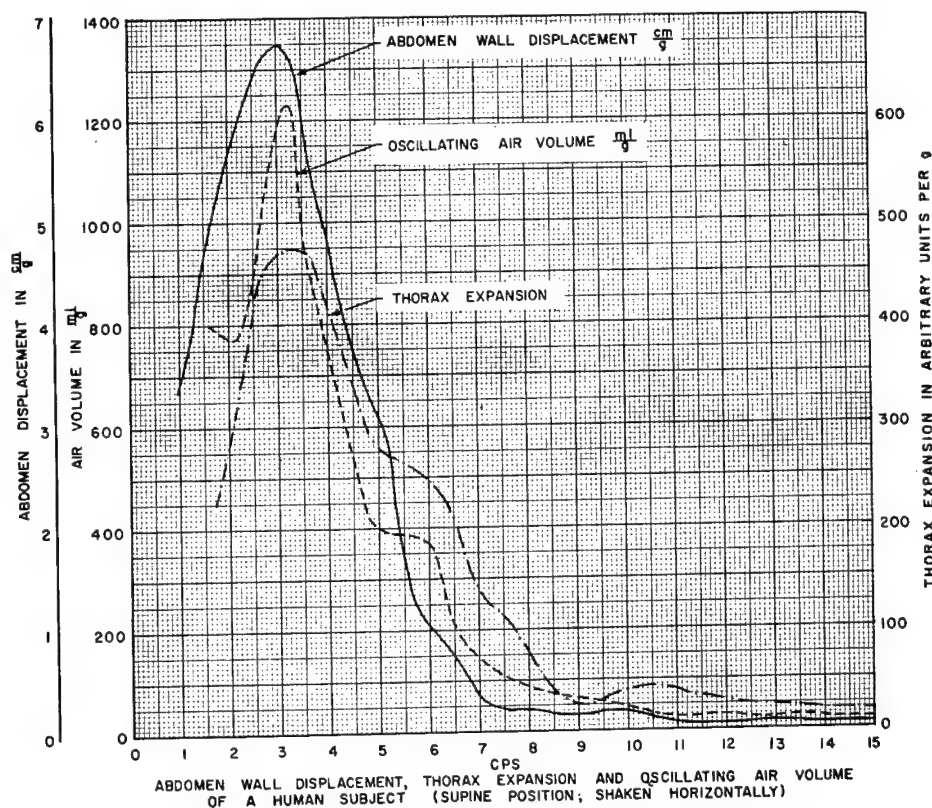


Fig. 5. (a) Typical response curves of the thorax-abdomen system of a human subject in the supine position exposed to longitudinal vibrations. The displacement of the abdominal wall (2" below umbilicus), the air volume oscillating through the mouth and the variations in thorax circumference are shown per g longitudinal acceleration.

mouth are shown for the condition studied in Figure 5a. The maxima of all these curves nearly coincide at a frequency which was between 3 and 4 cps. for all subjects studied. This shows the close coupling between the abdominal mass, the lungs and chest wall, and the air flow forced through the mouth. It is interesting to note

placement of the diaphragm was measured on x-ray pictures for the normal vertical position (+1 G) and for the subject standing on his head (-1 G). If a simple linear system is assumed, the resonant frequency of this system follows from this static displacement without further assumption of the mass or elasticity involved. The change

in the response curve—resulting from restricting the mobility of the abdomen is shown in Figure 5b; a resonant peak for the chest amplitudes ap-

the thorax-abdomen system. Fortunately, there are data available on the mouth-chest system of a subject in the supine position which were measured

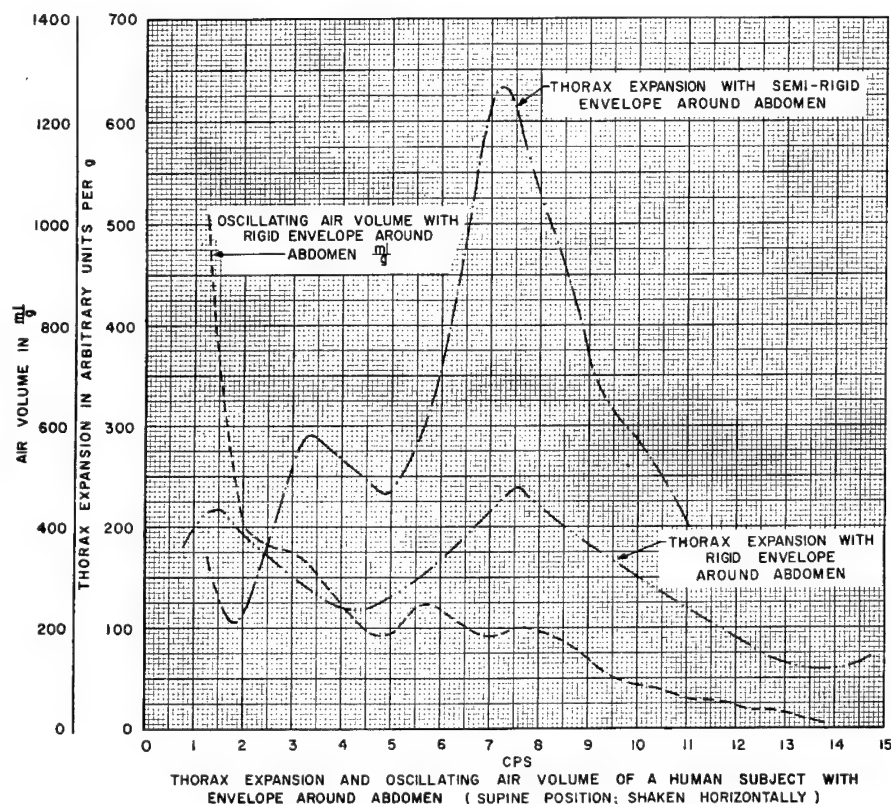


Fig. 5. (b) Response curves of the same subject shown in Figure 5a but with semi-rigid (tight fitting, non-elastic nylon girdle reinforced with stays) and rigid (plaster cast) envelope around abdomen.

pears around 7 cps. A similar peak appears for the expansion of the abdomen, when the chest motions are blocked (Fig. 5c), but in the latter case the maximum of the air flow shifts to very low frequencies.

Model of the Thorax-Abdomen System and Discussion.—The responses measured on the shake table are insufficient for the derivation of a model of

by DuBois et al³ by completely different methods and for other purposes. Because they were interested in the biodynamics of respiration, these investigators measured: 1. the impedance at the mouth by forcing a periodic alternating air flow through mouth and trachea into the lungs (they also observed chest and abdominal displacement due to this excitation); 2. the air flow through the open mouth or the

pressure in the closed mouth when alternating pressures were applied to chest and abdomen by putting the subject in a Drinker respirator. Re-exami-

estimated from the results of the various experiments. Using electrical analogue circuits instead of the mechanical systems and representing the

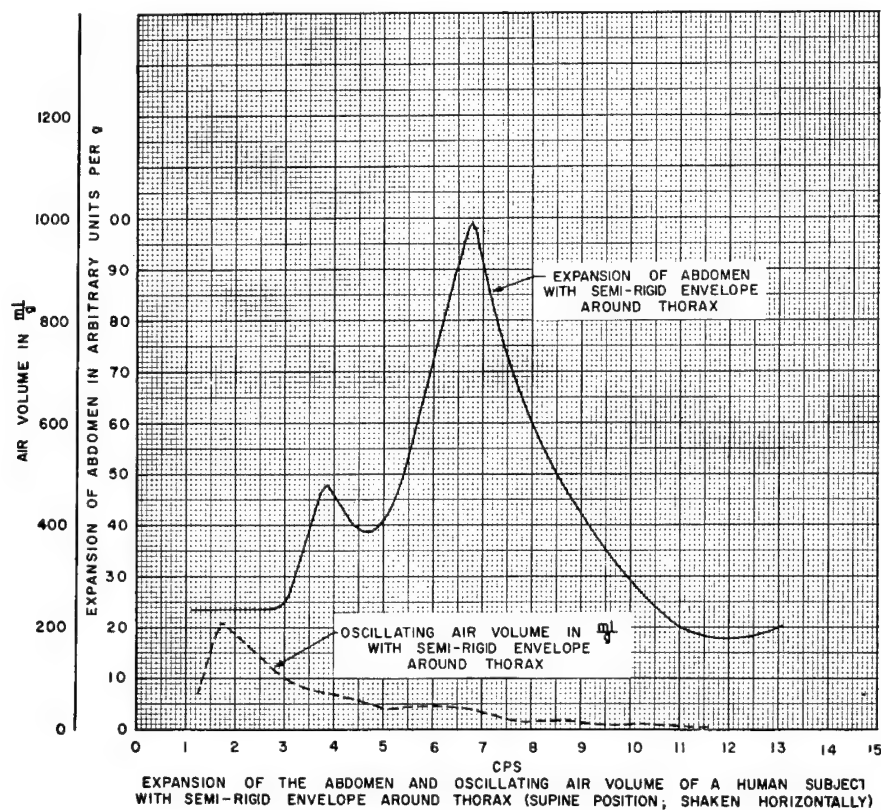


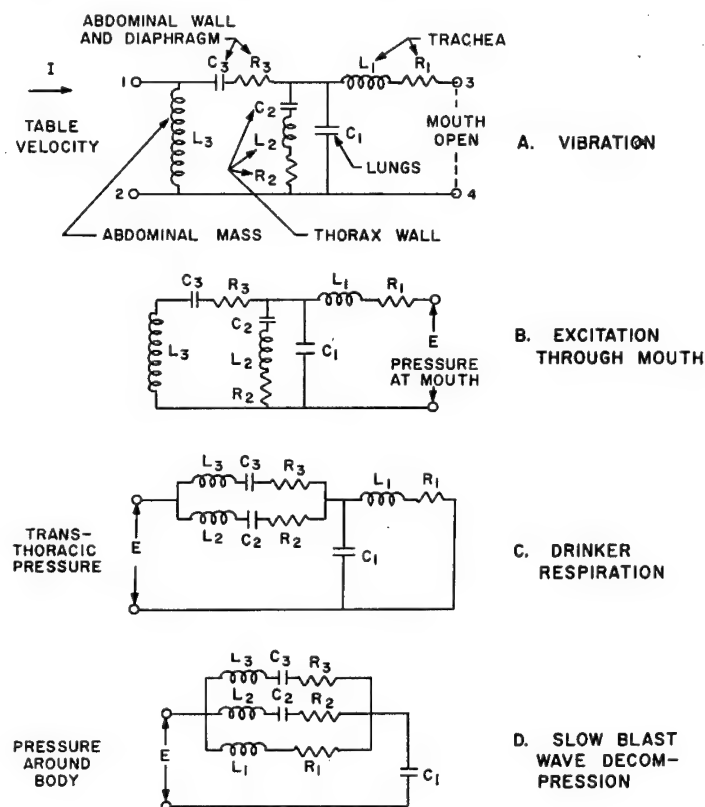
Fig. 5. (c) Response curves of the same subject shown in Figure 5a but with elastic girdle around thorax.

ning these data, measured in connection with respiratory studies in the light of the experiments reported here, it becomes obvious that both types of experiments are dealing with the same system of coupled circuits. Only the exciting forces are applied to different inputs of the system and the data have to be interpreted accordingly. The parameters of the system are the same for both cases and can be calculated or

system as a four-pole, we obtain the circuits of Figure 6A for the vibration excitation investigated here and the circuit of Figure 6B for the excitation through the mouth. In the first case, the circuit is excited by a current applied to the input terminals 1 and 2. This current is equivalent to the velocity exciting the mechanical system, which, under the assumption of a stiff skeleton and rigid connection to the

table, is equal to the table velocity. Terminals 3 and 4 are short circuited if mouth and glottis are held open. The current through $C_3 R_3$ corresponds to

with a pump, the exciting pressure corresponds to a voltage applied to terminals 3 and 4; terminals 1 and 2 are open for this condition. Using the



EXCITATION OF THE THORAX-ABDOMEN SYSTEM

Fig. 6. Electrical analogue circuits for the thorax-abdomen system exposed to: (A) vibrations, (B) oscillating air pressures applied to the mouth, (C) oscillating pressures around thorax and abdomen (drinker respirator), (D) varying pressure applied to thorax, abdomen and mouth.

the vertical abdominal velocity, the current through $C_2 L_2 R_2$ corresponds to the chest wall velocity, the current through C_1 corresponds to the velocity of oscillations of the lung volume, and the current through $L_1 R_1$ represents the flow velocity through the mouth. If the system is excited at the mouth

parameters DuBois et al measured for C_1 , L_1 , and R_1 , and estimating the other elements from the resonances and dampings observed in theirs and the present experiment, the responses to the two conditions can be calculated numerically. It is encouraging to see that the calculated responses for the

displacements in the various branches of the network display a behavior similar to the corresponding quantities measured on the body. This is illus-

et al for the chest-mouth system automatically predicts the observed chest wall and lung volume oscillations and the periodic air flow through the mouth.

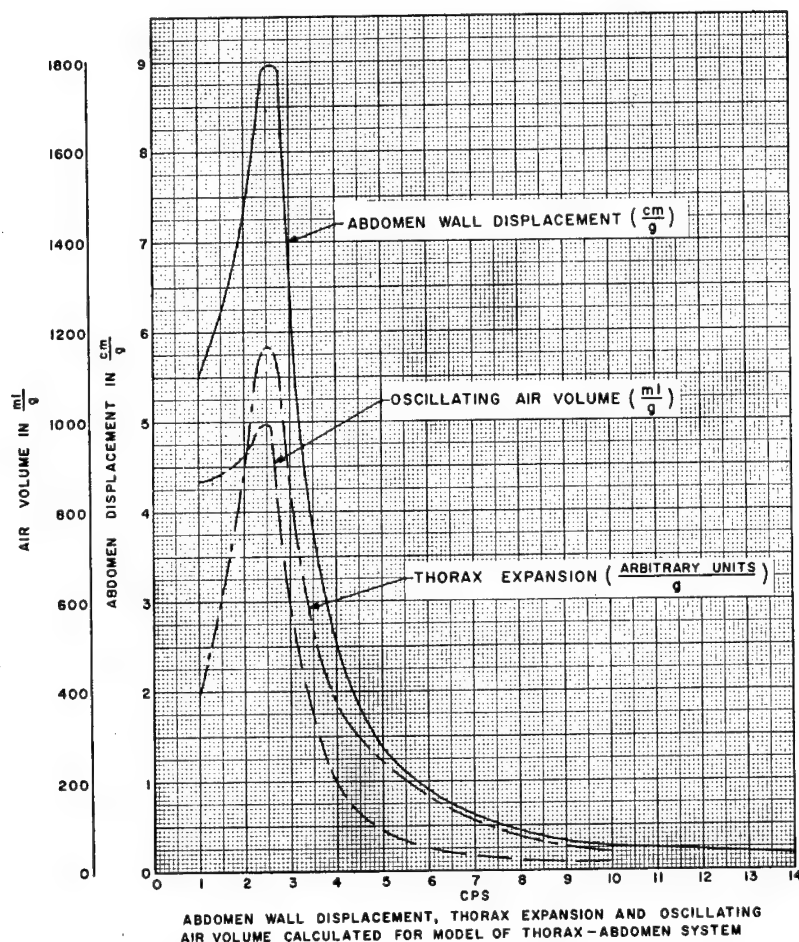


Fig. 7. Response curves calculated for the model of the thorax-abdomen system exposed to longitudinal vibrations (Figure 6A). The values for L_1 , C_1 , R_1 and L_2 , C_2 , R_2 were chosen within the range measured for these parameters by DuBois et al; L_3 , C_3 , R_3 were estimated from the present experiments. The characteristics of these response curves should be compared to the measured curves in Figure 5a.

trated in Figure 7 for case 6A; these responses should be compared with the response curves in Figure 5a. One sees that the use of the values of DuBois

Similarly the input impedance calculated for terminals 3, 4, can be compared with the measured data. Restricting the mobility of the chest cor-

responds to making the impedance of C_2 , L_2 , R_2 , very large et cetera. It is hoped that the circuit can be refined and compared with other experimental conditions. Excitation of the system by pressure around the chest and abdomen (Drinker Respirator) should correspond to the circuit of Figure 6C. The case of slowly rising blast waves or decompression, where mouth, chest and abdomen are exposed to the same pressure change should schematically correspond to the circuit of Figure 6D.

It must be kept in mind that body posture, harnesses, et cetera, will change the values of the parameters considerably. The values of DuBois et al and the data presented above apply only to the body in the supine position. For the sitting and standing position, considerable changes in the values for some of the parameters may occur; but there should be no doubt that the basic properties of the circuits would still be qualitatively correct. (The velocity exciting the abdominal system in Figure 5a was only under the condition of the reported tests equal to the table velocity. For other conditions, for example, the sitting subject, the transmission properties of the system between the exciting table motion and the abdominal system must be known in order to predict exactly the input to terminals 1 and 2 of Figure 5a.)

In addition, it is obvious that the assumption of lumped parameters, passiveness, and linearity are over-simplifications which limit the quantitative usefulness of the proposed circuits. On the other hand, they will certainly be helpful in understanding and predicting the response of the thorax-abdo-

men system under different loadings. This should apply particularly to transient loads. For example, the rush of air from the lungs which was observed in some downward ejection experiments⁷ follows directly from the steady state experiments (Fig. 5a). The circuits will help to predict the rise times for the acting force which are critical with respect to the response of the system, that is, that they result in overshooting.⁸

In a recent study of the short time tolerance to severe vibrations of human subjects in the sitting position, it was found that abdominal and intra-thoracic pain were the most frequent complaints and were definitely the limiting factors in the frequency range of lowest tolerance which is from 4-8 cps.⁹ Difficulty in breathing was another complaint, which was not as frequent due to the short time involved. All these symptoms point toward the importance of the thorax-abdomen system for human tolerance to vibrations. Although the connection between the tolerance limits on the one side and the impedance maximum (Fig. 2) and the resonance of the thorax-abdomen system on the other is obvious, quantitative interpretation of this curve awaits further study of the energy transmission from the system which determines the impedance of the sitting subject to the thorax-abdomen system.

The material presented in this paper should not be interpreted as an underestimation or disregard of the various biological and physiological processes, which are finally influenced or modified by the mechanical energy transmission exclusively discussed here, nor can the living, active response of the organism

to the mechanical environment be neglected. On the other side, it is just as obvious that a complete understanding of the physiological stimulation and effects is not possible without accurate, quantitative information on the dynamics of the body and on the mechanism of energy transport from the body surface to the ultimate receptor. Once a complete picture of the body as a dynamic mechanical transmission system is obtained, this system will be of extreme value regardless of the specific type of force application and the time function of this force.

SUMMARY

The physical and physiological effects of vibrations and impulsive forces applied to the body depend on the dynamic mechanical properties of the body. In order to obtain quantitative insight into the parameters of the mechanical body system, mechanical impedance measurements on sitting subjects were performed; the results of these measurements, which exhibit resonance maxima for the impedance at 5 and 11 cps., are presented with respect to the effective parameters of the circuit and the forces and energy transferred to the body.

Since vibration and impact injuries as well as subjective tolerances indicate that the thorax-abdomen subsystem of the body is very sensitive when excited by mechanical forces, a detailed study of this system on subjects in the supine position was made. Abdominal wall displacements, oscillating changes in chest circumference and periodic air flow through the mouth were measured for periodic, longitudinal vibration excitation. The resonance of all these re-

sponse curves is between 3 and 4 cps.

A generalized unified model of the total thorax-abdomen system is derived with approximate values for its constants. This model can be used to calculate the dynamic mechanical response to different types of force application: whole body vibration, respirator excitation and slow rising blast waves and decompression. Steady state as well as impulsive loadings can be studied on the circuit. This model may be used as a guide in future experimentation, in the interpretation of physical measurements and various types of damages and in developing and understanding protective measures.

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Factorial Structure and Validity of Naval Aviation Selector Variables

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ONE OF THE steps in processing applicants for the Aviation Officer Candidate Program and the Naval Aviation Cadet Program includes filling out the Bureau of Naval Personnel's Aviation Score Sheet. This form was recently designed to summarize the attributes, other than physical fitness, that are considered in screening candidates. The sheet provides a rating scale for interview results and other quantifications of essentially qualitative appraisals. In addition, educational background and aptitude are included.

The present study was designed to assess the effectiveness of the Aviation Score Sheet as an aid in selecting future flight successes. For this purpose, its component parts were investigated from the standpoint of factorial structure and validity in predicting pre-flight performance and attrition from flight training. The specific objectives of this research were: (1) to obtain the validity between the components of the score sheet and pre-flight and attrition criteria. (2) to define the factorial structure of component parts of the score sheet and the pre-flight and attrition criteria. (3) to indicate pos-

sible points of departure for future research in the selection of flight applicants.

PROCEDURE

Seven hundred and ninety naval aviation cadets and aviation officer candidates were used as subjects. These men entered training during the last half of 1957 and were the first for whom the score sheets were available. It should be noted that those men who were grossly unsatisfactory on the score sheet variables were not admitted thereby restricting the experimental population.

The Aviation Score Sheet consists of seven component scores and a total score. The components are as follows: (1) A Personality Rating, (2) The Aviation Qualification Test (AQT), which is an intelligence test,^{1,2} (3) The Flight Aptitude Rating (FAR), which is composed of three separate aptitude tests,¹ (4) The Selection Board Rating, (5) Past scholastic performance, (6) Credit hours in mathematics and physics courses, (7) Board Evaluation or references. Each applicant is assigned a numerical grade for each component in accordance with the grade scales on the sheet. These component grades are then summed to obtain the total score.

In addition to the specific score sheet

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ratings, the educational level of each subject was added to broaden the educational background picture. The Mechanical Comprehension Test (MCT), (1) still in program versus voluntary withdrawal and, (2) still in program versus flight failure. These coefficients presented in Table I showed that many

TABLE I. CORRELATION MATRIX

Variable		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Personality rating	1	—	.33	.06	.03	.52	.12	-.05	.06	-.08	-.01	.57	.11	.06	-.06	-.12
Selection board	2		—	.07	.13	.20	.11	.02	.09	.03	.08	.21	.08	.08	.07	.08
Scholastic standing	3			—	-.12	.18	.06	.06	.04	-.05	.03	-.19	.21	.15	.01	-.03
Mathematics and physics	4				—	-.07	.39	.27	.05	.01	.17	.18	.22	.02	.01	.08
Board evaluation	5					—	.01	-.07	.00	-.09	-.07	.42	.12	.07	-.08	-.08
Aviation Qualification Test	6						—	.37	.26	.03	.32	.16	.44	.12	.06	.03
Mechanical Comprehension Test	7							—	.28	.19	.68	-.12	.30	.07	.36	.22
Spatial Apperception Test	8								—	.11	.69	-.01	.20	.09	.29	.12
Biographical Inventory	9									—	.59	-.17	.12	.07	.23	.25
Flight Aptitude Rating	10										—	.13	.31	.11	.43	.29
Educational level	11											—	.03	-.05	-.09	-.18
PF ground grade	12												—	.57	.35	.23
PF Officer-like Qualities	13													—	.26	.08
Flight failure	14														—	.00
Voluntary attrition	15															—
X		1.3	1.8	1.2	1.1	1.5	76.8	59.6	19.5	31.7	5.9	7.0	51.5	51.6	—	—
		.4	.7	.5	1.1	.7	12.9	7.8	5.8	8.7	1.5	1.2	4.2	7.5	—	—

*Correlations of .07 and .09 are required for significance at the .05 and .01 levels, respectively.

†Education is coded as follows: 4 is H. S. graduate; 5 one year college; 8 four years college; 9 graduate school.

the Spatial Apperception Test (SAT), and the Biographical Inventory (BI) scores which comprise the Flight Aptitude Rating were considered as separate variables.

For criteria, attrition information and pre-flight performance data in the form of a pre-flight ground grade and the pre-flight officer-like qualities (OLQ) grade were utilized. These latter variables are not only criteria in that they define pre-flight performance, but past research has demonstrated that they are correlates of future performance in the flight program.^{4,7}

ANALYSIS

The first step in the analysis was to compute product-moment correlations between all variables except attrition variables. Biseri-als were also computed between the above variables and the two principal attrition dichotomies:

of the variables were significantly related to attrition. In terms of magnitude, however, the Flight Aptitude Rating and pre-flight ground grade were the best correlates.

Factor analysis was then used to help define the attributes being measured by these many variables and their collective relationship to the criteria. In order to complete the intercorrelation matrix for the factor analysis, it was necessary to have a correlation between flight failure and voluntary withdrawal. To bring out separate aspects of the two types of attrition the intercorrelation of zero was assumed.

RESULTS AND DISCUSSION

Five factors of varying degrees of distinctness were extracted from the matrix. Table II contains the rotated

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factor matrix. These factors were tentatively identified as follows:

Factor I.—Factor I was positively loaded on the three ability tests of the

Aviation Score Sheet that are essentially qualitative appraisals of the individual. These were Personality Rating, Board Evaluation or References, and the Selection Board Rating. In

TABLE II. FACTOR LOADINGS AFTER ROTATION

	I	II	III	IV	V*
Personality rating	.06	.80**	-.10	-.01	-.07
Selection board	.05	.47**	.15	.14	-.12
Scholastic standing	-.06	.03	.24	.28	.19
Mathematics and physics	.46**	.06	-.23	-.03	.13
Board evaluation	.04	.67**	-.25	.05	.10
Aviation Qualification Test	.59**	.12	.00	.04	.27**
Mechanical Comprehension Test	.62**	-.08	.04	.05	-.20
Spatial Apperception Test	.64**	.16	-.03	.02	-.18
Biographical Inventory	.08	-.04	-.05	.42**	-.09
Educational level	.01	.70**	-.09	-.21	.29**
PF ground grade	.58**	.06	.58**	.25	-.29**
Officer-like Qualities	.39**	.05	.57**	-.06	-.08
Flight failure	-.41**	.08	-.21	-.09	-.29**
Voluntary attrition	-.24**	.12	.15	-.29**	.22**

*The fifth factor was merely reflected not rotated.

**These loadings contributed to the interpretation of the factor.

aviation selection battery. These were the Aviation Qualification Test, the Mechanical Comprehension Test, and the Spatial Apperception Test. In addition the pre-flight ground grade, the officer-like qualities grade, and mathematics and physics credit hours loaded here.

Of major importance to the interpretation of Factor I was the flight failure criterion with a loading of $-.41$. This negative loading meant that individuals high on other Factor I variables were less apt to fail and those low were more apt to fail. The voluntary withdrawal loading on this factor was $-.24$ which indicates some relevance to this factor also. Since Factor I was identified with both pre-flight and flight criteria and since past research has shown pre-flight to be predictive of flight performance,^{4,7} it was named "Flight Ability."

Factor II.—Factor II had high loadings on the three variables from the

addition Educational Level clustered with these three.

The Personality Rating score is a composite of five traits. Descriptive phrases are used as a guide for the rater—a senior naval officer—to help him in assigning each ratee a score on each trait. Examination of the rating scale's descriptive phrases indicates that the highest score will be given to those individuals who are mature in appearance, composure, voice quality, vocabulary usage, and goals in life.

The Board Evaluation is a composite of the responses of the references submitted by the prospective flight candidate. He is rated on thirteen traits such as the ability to make logical decisions, ability to originate and act upon his own ideas, reaction to frustration, ability to lead others, degree of cooperation, emotional characteristics, attitude toward his work, and integrity. Here again, it is obvious that the highest scores will go to those giving a mature impression.

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The Selection Board rating is made by at least three officers and includes ratings on such items as "intellectual normality," "absences of neurotic or psychotic symptoms," and "emotional maturity." Here again apparent maturity would gain a high score.

It was reasonable therefore to label Factor II "Appearance of Maturity." There was no evidence here that measures of this factor had any common variance with either the attrition or pre-flight performance criteria.

Factor III.—Factor III had positive loadings for two variables previously loaded on Factor I. The pre-flight ground grade and the officer-like qualities grade. Since the aptitude measures, especially the Aviation Qualification Test, and the attrition criteria did not appear with this factor, it was evident that it was apart from scholastic or flight proficiency. This left military proficiency as the alternative since it constituted 19 per cent of the ground grade and 33 per cent of the officer-like-qualities grade. For this reason Factor III was called "Military Conduct."

Factor IV.—Factor IV had only one high positive loading—the Biographical Inventory. This BI contains questions on childhood and growing up, practical judgment, aviation knowledge, various interests, attitudes toward flying, and how much the applicant likes to "rough it." The test is scored so that those with a history of early independence and experiences in risk-taking and with a present interest in things which require risk-taking receive the highest scores. While the loading for volun-

tary withdrawal was not large, only —.29, it was the next highest loading on this factor, indicating that some of the trainees probably dropped from the program because of the risk aspect. Since the BI is considered to be a non-ability test and since the voluntary withdrawal criterion, which is officially termed lack of motivation, was associated with it, this factor was titled "Motivation to Take Risks."

Factor V.—The loadings on Factor V were of relatively small magnitude. They held some interesting ramifications with respect to the criteria and future research, so instead of calling it a residual, an interpretation was made. The highest positive loadings were Educational Level and the Aviation Qualification Test or the AQT. The AQT previously loaded on Factor I without Educational Level. Therefore, this factor contained that element measured by the AQT common to educational level. This element might represent a portion of the AQT which is tapping some non-ability attribute, since in Factor I the AQT clustered in a positive direction with the pre-flight grade, that is, academic achievement, while in Factor V the pre-flight grade was negatively loaded. Furthermore, this factor was negatively loaded on flight failure but positively loaded on voluntary withdrawal. Broadly interpreted these findings mean that students high on this factor had sufficient ability to keep from failing, but they tended to resign on their own volition. This coupled with the tendency for students high on this factor to perform poorly in pre-flight hints at some aspect of motivation.

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The positive loading of .19 for scholastic standing and .13 for mathematics and physics credit hours coupled with the other loadings already discussed

cal Comprehension Test, and the Spatial Apperception Test clustered in Factor I. Mathematics and physics credit hours was the only other score

TABLE III.
PORTION OF CRITERIA VARIANCE EXPLAINED BY EACH FACTOR

Factors	Criteria			
	PF-GR*	OLQ**	FF***	VW****
I Flight ability	33.6%	15.2%	16.8%	5.8%
II Appearance of maturity	0.4%	0.3%	0.6%	1.4%
III Military conduct	33.6%	32.5%	4.4%	2.3%
IV Motivation to take risks	6.3%	0.4%	0.8%	8.4%
V Academic interest	8.4%	0.6%	8.4%	4.8%
Unexplained s ²	17.7%	51.0%	68.9%	77.3%

*Pre-flight ground grade.
**Officer-like qualities.
***Flight failure attrition.
****Voluntary withdrawal attrition.

could mean that this factor represents the desire to pursue academic goals different from those offered in aviation. For this reason, Factor V was named "Academic Interest." The identification of this factor and its subtle relation to the problem of motivation suggests a point of departure for future research into the ever present problem of motivation in flight training.

SUMMARY AND CONCLUSIONS

To summarize, Table III was prepared to show the portion of criterion variance explained by each factor. With respect to pre-flight ground and OLQ, Factors I, Flight Ability, and III, Military Conduct, of course accounted for most of the explained variance.

As expected from the relatively low factor loadings, most of the attrition criterion variance is yet to be explained. Factor I accounted for most of that which was explained. The Aviation Qualification Test, the Mechan-

sheet variable in evidence here. The small contribution it made probably stemmed from the correlation of .16 with cadet voluntary withdrawal. There was a unique quality about this variable since the other two educational variables did not cluster with Factor I.

Factor IV, Motivation to Take Risks, explained a little of the voluntary withdrawal variance. Factor V, Academic Interest, likewise explained a little of both the voluntary withdrawal and flight failure variance, but the prediction accomplished by Factor V is actually at cross-purposes. In effect, voluntary withdrawal attrition would be increased by having predictor variables saturated with Factor V and flight failure would be decreased.

As evidenced further from Table III, the contribution of Factor II, Appearance of Maturity, toward explaining any criterion variance was negligible. The qualitative appraisals all clustered here. This finding does not actually preclude their usefulness, however. This experimental group con-

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sisted of individuals judged acceptable on the score sheet variables. It is a fair assumption that the obvious misfits were eliminated by these measures. Furthermore, there is a possibility that this type of material might relate to later operational proficiency.⁵

The results of this research led to the following conclusions: (1) Among the variables considered, the aviation selection tests were the best predictors of the pre-flight performance and the attrition criteria; (2) In addition, the mathematics and physics credit hours from the Aviation Score Sheet had some validity. It was recommended that this variable be retained as a selection variable especially in view of the recent increased emphasis on the basic sciences in the training program; (3) There was no evidence from these data to support the qualitative appraisal variables on the Aviation Score Sheet. However, it was recommended that these variables be further validated against flight proficiency and fleet proficiency before final judgment is made concerning their utility as refined predictors; (4) The identification of Factor V, with a positive loading on volun-

tary withdrawal and a negative loading on flight failure and with other loadings that are indicative of a non-ability attribute, suggests a point of departure for future motivational research.

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This Message Bears Repeating

Whenever possible, it is advisable that a flier or prospective airline passenger with an acute upper respiratory infection be "grounded" temporarily until the condition improves. Persons with allergies, chronic tonsillitis, or sinusitis should abstain from flying and have these situations corrected, unless they are mild or asymptomatic. An active sinusitis in flying personnel may produce symptoms in the air although remaining symptom-free on the ground, and the symptoms of an active sinusitis may be expected to be aggravated by flying. It warrants reiteration, also, that any person who has had a recent acute attack of aerotitis should postpone flying until the middle-ear tissues have returned to complete normalcy.—DAVID CHARLES SCHECHTER: Aerotitis Media, *Archives of Otolaryngology*, August, 1957.

The Incidence of Hypoglycemia in Flight

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HYPOGLYCEMIA has been implicated as a cause of accidents involving pilot error. Several cases have been reported by Lawton^{2,3} in which near misses, incidents, and accidents in the Flying Training Air Force appear to have been caused by pilot incapacitation due to hypoglycemia. Further investigation led Lawton² to the conclusion that this may well have produced the marked increase in aircraft accident rates in the latter half of the morning as compared to the early half.

Relative hypoglycemia produced by a carbohydrate breakfast has been shown by Brent et al.¹ to be additive to the common physiologic disturbances of moderate hyperventilation and positive accelerative forces, leading to a high incidence of loss of consciousness in normal pilots. The question remaining to be answered is, does this relative hypoglycemia occur in normal pilot population, and if so, what is the incidence?

Several studies have previously been made on blood sugar levels of various pilot populations. One study⁸ made on a group similar to the one used in this study failed to reveal any cases of relative hypoglycemia; measurements were made by a clinical laboratory on venous blood specimens. Two larger studies have been reported by Robbins⁶

and Robbins et al.⁷ These intensive studies failed to show any correlation between blood sugar changes and dietary histories. One should not expect to find a definite case of hypoglycemia in the several hundred subjects observed in view of the very low pilot error accident rate in the Air Training Command; even if all pilot error accidents were due to hypoglycemia, in 1955 this would have been one accident in every 8,620 flights of two hours duration.

These very excellent and intensive studies required some additional field studies to build up the number of cases observed. A population was selected that had well controlled and homogeneous in-flight stresses, flight durations, times of take-off, flying experience and age.

METHOD

Two single engine (T-33) basic flying training bases in Texas were selected for study. Blood specimens were obtained from students and instructors before and after flight with virtually 100 per cent cooperation. These specimens were obtained by finger puncture of sufficient depth to avoid undue squeezing of the finger. The blood glucose concentrations were measured according to the micro-method of Miller and Van Slyke.⁵ Following the last finger puncture of an individual, he was given a questionnaire, requesting name, rank, serial number,

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total and jet flying experience, marital status, type of quarters, time in and out of bed the preceding night, times of take-off and landing, and complete

TABLE I. SUMMARY OF BLOOD GLUCOSE VALUES, GIVEN IN MILLIGRAMS PER CENT, OBSERVED IN THE STUDY

	Flight 1	Flight 2 Only	Flight 2, After Flight 1
Preflight mean o N	132.3 ± 22.3 87 persons	122.0 ± 16.7 102 persons	119.4 ± 23.5 23 persons
Postflight mean o N	114.4 ± 17.5 91 persons	114.0 ± 17.1 87 persons	115.1 ± 18.0 23 persons
Mean in-flight change o N	-17.6 ± 28.3 84 persons	-10.3 ± 22.0 86 persons	-3.48 ± 22.0 23 persons

dietary intake of the preceding twenty-four hours. Some subjects made two flights the same morning; three specimens were obtained from these persons, one before the first flight, one between flights and one after the second flight. No subject was used more than one day. No explanation of the experiment was made to any subjects until after gathering of data was completed. While obtaining the post-flight blood specimens, the subjects were observed for signs of hypoglycemia.

RESULTS

Of the 193 person-flights in which pre- and post-flight blood sugars were obtained, no individuals were found to have or to have had in-flight or post-flight signs or symptoms of hypoglycemia.

A mathematical description of the blood sugars obtained is shown on Table I. The distribution of blood

sugar values is shown in Figures 1 through 9.

A change of more than 60 mg. per cent was found in fifteen cases; two were increases and thirteen were decreases. Of the thirteen who had decreases of more than 60 mg. per cent, eleven had returned their questionnaires with sufficient information for the evaluation of diet. It was found that four of the eleven had had a breakfast of considerable sugar and other carbohydrate with no protein, or a sugar-carbohydrate breakfast incidence of 36.4 per cent. In addition, two more had consumed a very large amount of sugar for breakfast along with a minimal amount of protein. Only one denies eating sugar; his meal was of high carbohydrate content. By contrast, of the 134 other respondents, only thirteen had had no protein preceding the flight, or a sugar carbohydrate breakfast incidence of 10 per cent. Lesser changes in blood glucose levels correlated poorly with dietary history.

Diet was directly correlated with commission status; cadets almost invariably ate a well-balanced breakfast, since they must eat in the cadet mess hall. Student officers and instructor pilots were not nearly as consistent in their eating habits, but most managed to get milk and some other protein for breakfast. No significant difference was found between instructors, student officers, and cadets, other than associated with diet.

The amount of sleep obtained the night before did not correlate with rank, marital status, diet, alcohol intake, or blood sugar changes. The mean number of hours in bed was

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6.86 (six hours and fifty minutes), with extremes of 4.5 to 9.5 hours.

DISCUSSION

The primary purpose of this project was to determine the incidence

fidence limits, in the population sampled. The incidence in this study was zero per cent. Since no difficulties were encountered in-flight, this data cannot be used to prove that various episodes occurring in-flight are or are not due to hypoglycemia.

Present day studies in aircrew members should not be interpreted either as proving or disproving that hypoglycemia was contributing to the high

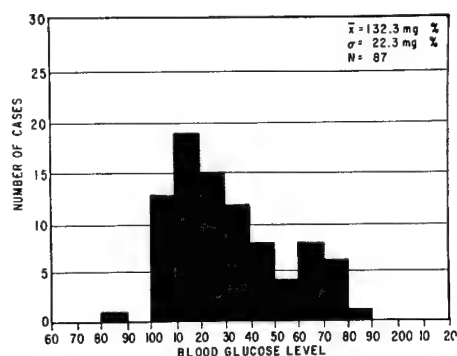


Fig. 1. Distribution of blood glucose levels. Preflight values in those flying the first period.

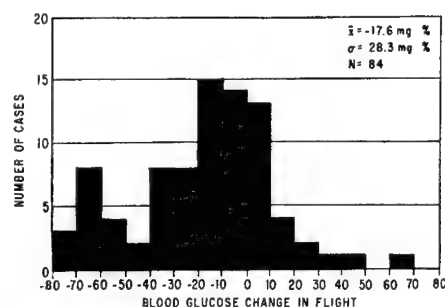


Fig. 3. Distribution of in-flight changes in blood glucose levels. Changes during the first period.

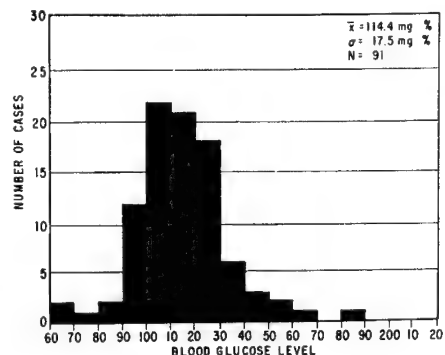


Fig. 2. Distribution of blood glucose levels. Postflight values in those flying the first period.

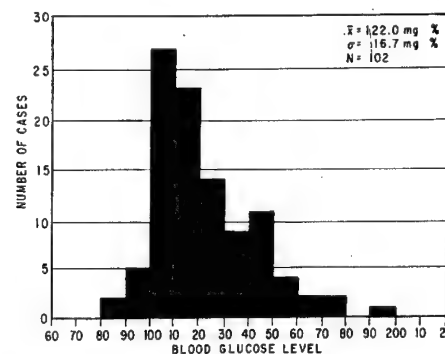


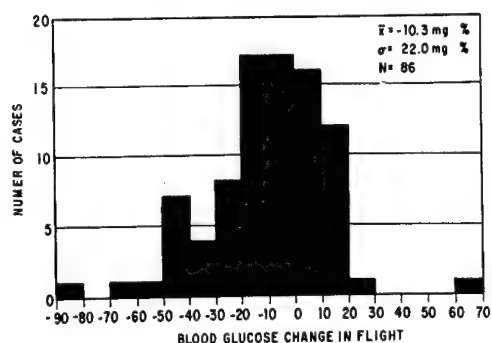
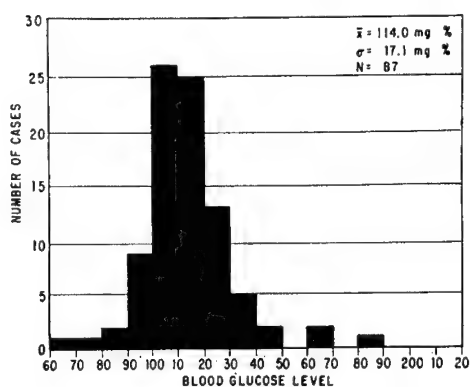
Fig. 4. Distribution of blood glucose levels. Preflight values in those flying the second period only.

of hypoglycemia. No clinical cases were found, and no unusual difficulties were encountered by the flying personnel while under study. Therefore, relative hypoglycemia, if it does exist at all, has a true incidence (p) of between 0.00 per cent and 1.54 per cent of flights with 95 per cent con-

accident rates experienced by Flying Training Air Force prior to July, 1955; it is certain that now in single engine jet basic training, hypogly-

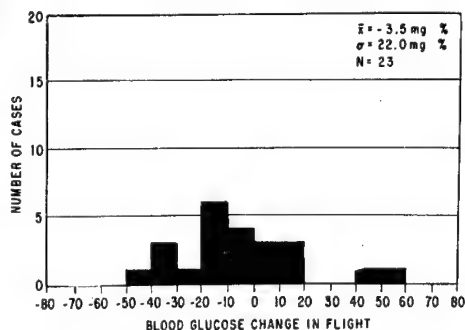
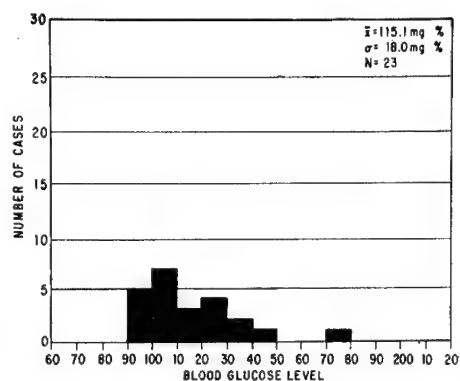
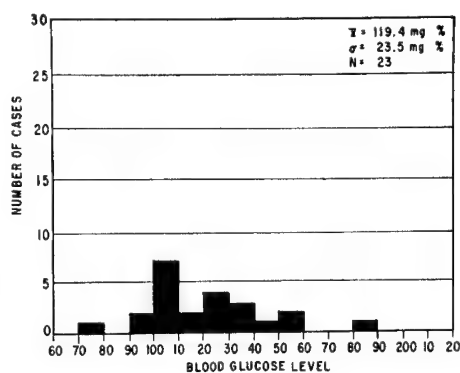
HYPOGLYCEMIA IN FLIGHT—TAYLOR

cemia is uncommon if it exists at all. The heavy emphasis upon a good breakfast has been made for several years, and the correction of cadet diet deficiencies has probably already greatly altered the picture of carbohy-



drate metabolism in the student pilots.

In spite of the emphasis placed upon teaching pilots adequate dietary habits, it is apparent from the study that once the pilots have completed this training, many revert to an undesirable diet. If one grants that a sugar or other car-



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bohydrate breakfast, in association with moderate hyperventilation and aircraft maneuver, can lead to loss of consciousness (or even just difficulty in flight coordination), then the incidence of carbohydrate breakfasts shown in this study is of importance. As long as an appreciable number of aircrew members are eating improperly, these persons must be sought out and their dietary habits reformed.

A definite relationship of diet to marked decreases in blood glucose levels was found in this study, in contrast to other similar studies previously made. This may be due to several factors: 1. The use of arterial blood minimizes the effect of changes in the peripheral vascular system which are readily seen post-flight, 2. The use of a population flying a regular schedule means there will be less clouding of data by the important variables of time interval between eating and flying, and duration of flight, and 3. The essentially homogenous nature of the population was such that the students and instructors fell within very narrow ranges of age, flying experience, physiological training, personal equipment maintenance, and attitudes towards flying safety and general hygiene. Due to the essential difference between capillary blood sugar determinations done in this study and venous blood sugar determinations done in other studies, it is suggested that direct comparison of the data from this experiment with other studies be made with considerable caution.

Mean values of pre-flight blood sugars were significantly higher in the first flight period than the second; post-flight mean blood sugar values

were virtually identical. The mean in-flight change in blood sugar concentration was a drop of 18 mg. per cent in the first flight period, 10 mg. per cent in the second period, and only 3.5 mg. per cent in the second period in those flying both periods. The probability of the differences of in-flight changes being due to chance alone is between 5 and 10 per cent. Hence hypoglycemia is to be expected in the early rather than the latter part of the morning.

One possible flaw in the experimental design is the assumption that the blood obtained by finger puncture before flight, which is essentially arterial blood in appearance and composition, is comparable to the blood taken by finger puncture post-flight. The post-flight specimen may, for example, consist of a more venous blood, although there was no marked difference in color. Because of the difficulty in obtaining true arterial blood, this particular question has not been investigated during this study.

The general deficiency in sleep before flying merits consideration. For many persons, almost seven hours in bed may be sufficient rest, but it is difficult to believe that persons having had only four point five to six hours of rest are as capable in-flight as they would have been if they had received a full eight hours of sleep. It does not seem likely that the half of the sample group who had received less than six hours and fifty minutes of time in bed were in top physical condition. It may well be that more accidents are caused by falling asleep, drowsiness, or even just fatigue than are caused by hypoglycemia.

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SUMMARY

By the use of clinical criteria no cases of in-flight hypoglycemia were found in 193 subject flights at two single engine jet training bases.

Thirteen instances of a decrease of over 60 mg. per cent in-flight were found by measuring capillary blood sugar immediately before and after flight. The eleven in this group that could be evaluated had had a breakfast of greater sugar and carbohydrate and lower protein content than had normals.

In-flight decreases in blood sugar levels were greater during the first morning flight period than during the second part.

In-flight changes in blood glucose concentration were correlated with diet and with commission status.

Rest the night before flight was of a mean duration of 6 hours and fifty minutes, with extremes of 4.5 to 9.5 hours.

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Spontaneous Pneumothorax

The "average" patient who has a spontaneous pneumothorax at ground level usually has a moderate amount of chest discomfort, some dyspnea on effort, and perhaps a cough. He is usually physically able to seek medical advice on his own, and to receive proper care without too much difficulty. In flying personnel, first, there may be an increased frequency of initial pneumothorax due to recurrent exposure to altitude. Second, if the spontaneous pneumothorax should occur at altitude, the already existing problem of hypoxia is greatly magnified. It may be severe enough to result in the abortion of a mission or in an aircraft accident.—GEORGE DERMKSAN and LAWRENCE E. LAMB: Spontaneous Pneumothorax in Apparently Healthy Flying Personnel. *Annals of Internal Medicine*, July 1959.

A Review of Available Information on the Acoustical and Vibrational Aspects of Manned Space Flight

HOWARD I. JACOBS

THIS PAPER is a review of the problem of noise and vibration with respect to manned space flight. For the purposes of this discussion, noise will be defined as the energy transmitted to a man through the air at all frequencies up to 15,000 cps. Vibration will be defined as all of the energy transmitted to a man through the structural components for all frequencies above 0.5 cps. The separation of noise and vibration with respect to space vehicle problems in this report is entirely a matter of convenience. The sources of the vibration and noise impinging upon a man in a vehicle are ultimately one and the same. Fluctuating pressure levels from several sources cause the capsule structure to vibrate, which results in the transmission of this energy through the air as noise, and through the seat structure as vibration.

NOISE ENVIRONMENT CONNECTED WITH SPACE VEHICLE OPERATIONS

Powered Flight.—A general analysis of the powered flight acoustic environment external to the capsule for a theoretical space vehicle mission has been made by Hoeft and Leech.⁷ As they pointed out, there are two primary sources of noise in the region of the missile, the rocket engine jet and

the boundary layer turbulence or aerodynamic noise. Both produce a wide-band random noise with essentially no pure tones. The noise problem changes throughout the mission as the relative contribution from these sources change. Hoeft and Leech make the following assumptions for their analyses: 1. The vehicle will contain two or more stages, with an initial thrust/drag ratio of 1.5, following a hyperbolic curve until burnout. First stage will terminate at 100,000 to 300,000 feet with a burnout velocity of 10,000 ft./sec., 2. The space vehicle will have a diameter of from 7 to 15 feet, length from 70 to 125 feet, and 3. The occupant will be located in the nose cone portion of the vehicle.

The over-all acoustic power from the rocket engines was predicted on the basis of Figure 1, taken from a study by Cole, Von Gierke, et al.⁸ This prediction scheme tends to give a high acoustic power figure because of the assumption that the mechanical to acoustical efficiency increases with thrust. Certain aerodynamic arguments indicate that the efficiency will level off at 1 per cent. Nevertheless, the approximation is close enough for the purpose. Figure 2 shows the predicted acoustic power level spectrum for three large rockets.

A characteristic of rocket noise is

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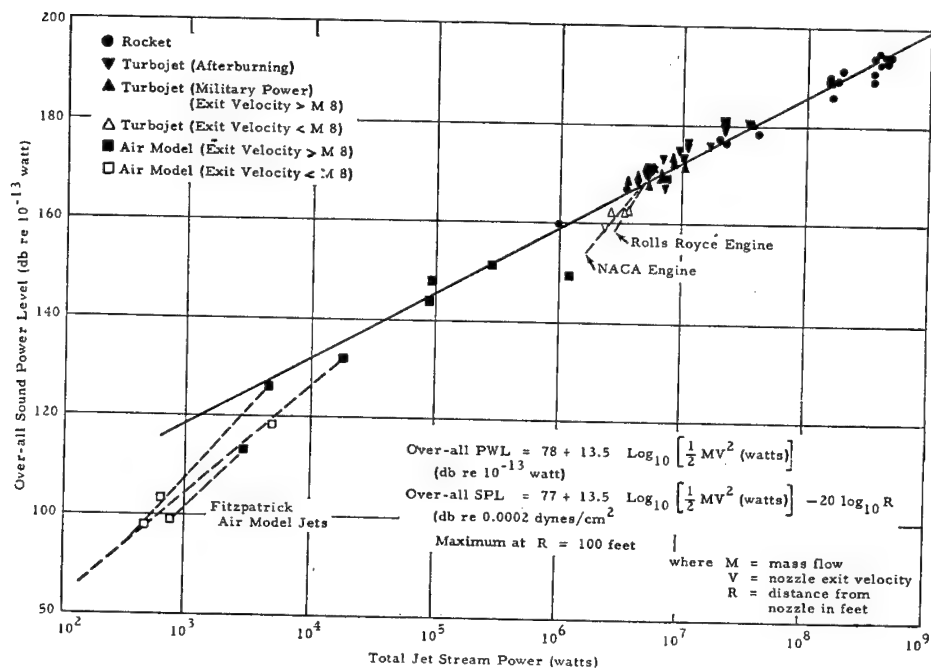


Fig. 1. The over-all acoustic power of engines.

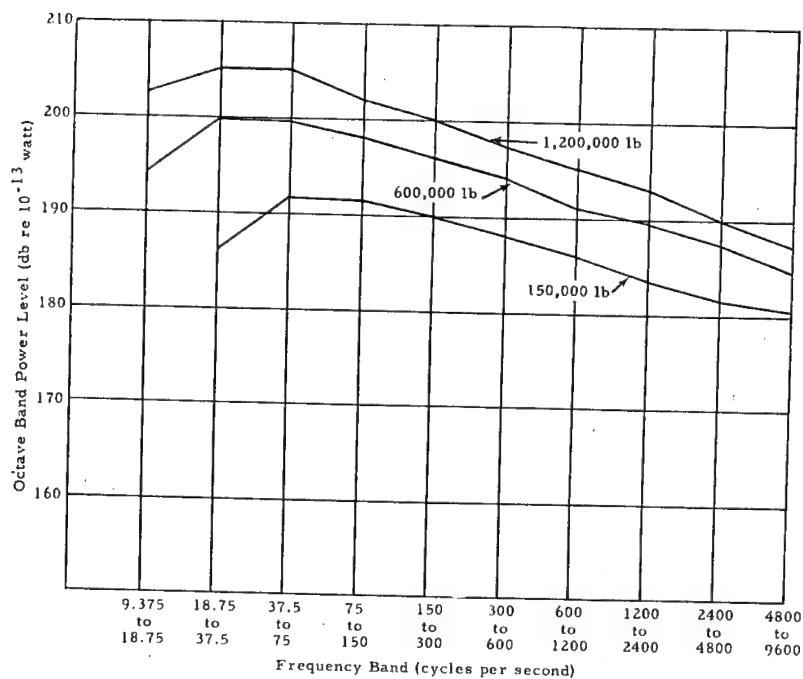


Fig. 2. Predicted acoustic power level spectrum for three large rockets.

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its directivity. Directivity indices, for 0° and 90° from the nose of the vehicle (Table I), were used in calculating the sound pressure level for measurements on sleds and aircraft have validated the correlation between aerodynamic noise and indicated air speeds up to at least Mach 1.8, with

TABLE I. DIRECTIVITY INDICES AT ONE HUNDRED FEET

TABLE I. DIRECTIVITY INDICES AT ONE HUNDRED											
Position	Frequency Band										
	O/A	9.375/ 18.75	18.75/ 37.5	37.5/ 75	75/ 150	150/ 300	300/ 600	600/ 1200	1200/ 2400	2400/ 4800	4800/ 9600
0° (nose)	-12	-14*	-14*	-14	-15	-12	-12	-16	-14	-12	-10
90°	-2.5	-3*	-3*	-5	-2	-2	-2	0	+1.5	+1	+2

*Not based on measured data.

each octave band at the outside of the nose cone by the following formula:

OB SPL=OB PWL-10 log A DI where
OB SPL=octave band sound pressure level in db,
re: 0.0002 dynes/cm²

OB PWL=octave band acoustic power level in db,
re: 10⁻¹² watts

DI=directivity index in db

A=4πR² when the source is radiating into free space (i.e., considerably above the ground).

The sound pressure levels thus calculated for a space craft with engines of 150,000 pounds thrust under static firing conditions are shown in Figure 3. The sound pressure levels are shown as bands rather than points because the geometry of the launch stand configuration introduces uncertainties as to the amount of energy reflected from the ground (probably no more than 3 db). The effect of launching on the acoustic environment is also shown in Figure 3. The difference between static firing and launch condition is 10 lb in the low frequency bands and 15 db in the high frequency bands.

The second major source of noise in space vehicles is aerodynamic noise or boundary layer turbulence. Recent

TABLE II. PREDICTION SCHEME FOR AERODYNAMIC NOISE OUTSIDE OF A NOSE CONE

Bands	Formulae
300/ 600 cps	SPL=55 log ₁₀ IAS-33±4
600/1200 cps	SPL=55 log ₁₀ IAS-25±4
1200/2400 cps	SPL=55 log ₁₀ IAS-21±4
2400/4800 cps	SPL=55 log ₁₀ IAS-22±4
4800/9600 cps	SPL=55 log ₁₀ IAS-25±4

SPL=octave band sound pressure level in db re 0.0002 dyne/cm² at outside skin of nose cone.
IAS=indicated air speed in ft/sec.

some erratic behavior around Mach 1. Although a good prediction scheme is not available at the present time, the present measurements allow an approximation of the noise generated by the boundary layer turbulence. Aerodynamic noise is predominantly high frequency noise. Table II gives Hoeft and Leech's prediction scheme for sound pressure levels at the outside surface of the nose cone. This scheme was derived by subtracting 5 db from the levels predicted by Rogers⁹ whose calculations are for a noise source relatively closer to the man. The prediction scheme is based on the premise that the aerodynamic noise will increase with the 2.75 power of velocity. Various measurements indicate that the sound pressure level varies as the

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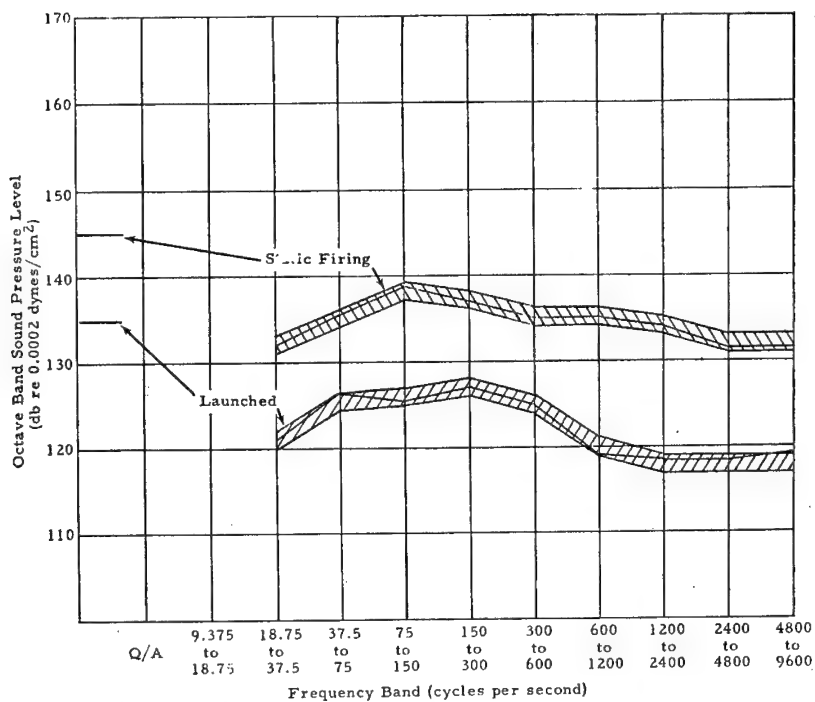


Fig. 3. Predicted sound pressure levels at nose cone for static firing and launched conditions (150,000 lb. thrust rocket).

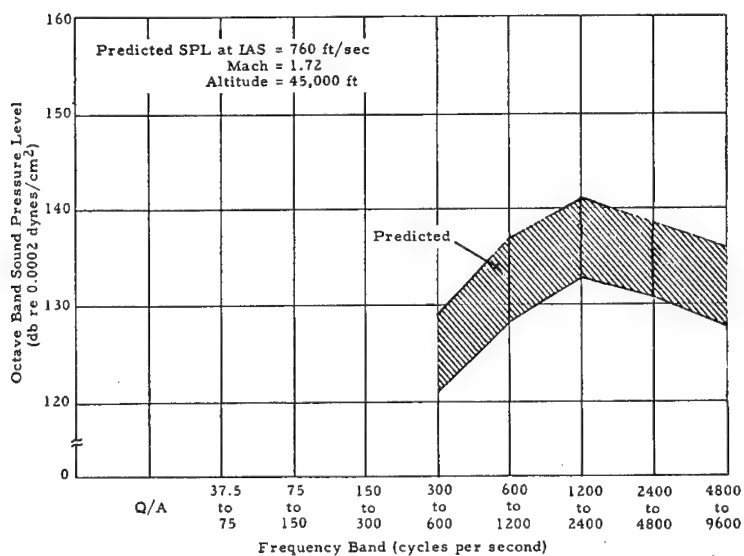


Fig. 4. Predicted sound pressure levels outside of nose cone.

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second or third power of the velocity and $v^{2.75}$ is a good approximation.

In the range of Mach 0.9 to 1.1, the sound pressure levels toward the rear of the missile may increase up to 20 db because of shock wave formation; however, this is generally not true near the nose.

Figure 4 shows the calculated maximum sound pressure level for Hoeft and Leech's hypothetical mission which occurred at an altitude of 45,000 feet, a true air speed of 1650 ft./sec., an indicated air speed of 760 ft./sec., a Mach of 1.72 and an elapsed time of 65 seconds after launch. When the vehicle reaches speeds above 10,000 ft./sec. it is out of the atmosphere and the major sources of noise are not in operation. Another source of noise inside the capsule results from vibrational energy transmitted from the rocket engine through the structural elements of the vehicle to the capsule. The effect of this "internal noise source" is relatively minor.

Re-entry Noise.—In the presentation by Hoeft and Leech, no predictions of re-entry aerodynamic noise were made. Callaghan² reported some theoretical calculations of the sound pressure levels expected inside the capsule during the re-entry of a blunt nose ballistic vehicle of 3000 pounds from an orbit of 150 nautical miles. He stated that the maximum sound pressure level would be 146 db and would remain above 130 db for approximately fifty seconds during the re-entry. Recently he revised his figures downward to a maximum of 130 to 135 db.

Summary of Predicted Data.—We may consider the following conditions

as representative of the probable acoustic environment for space capsules.

Condition

- (1) Launch
- (2) Ascent
- (3) Re-entry

Duration

5 to 10 sec.
2 min.
30 to 50 sec.

Peak Over-all Pressure Level

150 db external—135 internal
140 db external—125 internal
140 db external—125 internal
135 db external—120 internal

The nature of the capsule construction will, by the best available estimates, afford 15 to 20 db attenuation of the external acoustic environment.

The type of analyses presented above is applicable to the types of space vehicles and missions that are predicted in the foreseeable future. The degree of accuracy has been experimentally shown to be sufficient for human factors analyses and will permit the engineer to set up adequate acoustic design criteria in the development of manned space vehicles.

Human Tolerance to Noise, Permanent Effects.—The effect of noise on the human ear involves three major parameters; intensity, duration of exposure, and frequency characteristics. "Damage-risk criteria" defining minimum noise levels, above which permanent hearing is impaired, have been proposed by Rosenblith and Stevens,¹⁰ for random noise such as produced by jets and rockets (Fig. 5). These criteria only apply to "lifetime" exposures, that is, eight-hours per day over months and years. They are included in this report because of their

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possible usefulness to ground test personnel at missile bases and test stand facilities. Eldred, Gannon, and Von Gierke⁵ have proposed "short-time ex-

Figure 6 presents their criteria in terms of maximum permissible continuous over-all sound pressure level in db, re: 0.0002 dynes/cm.,² for expo-

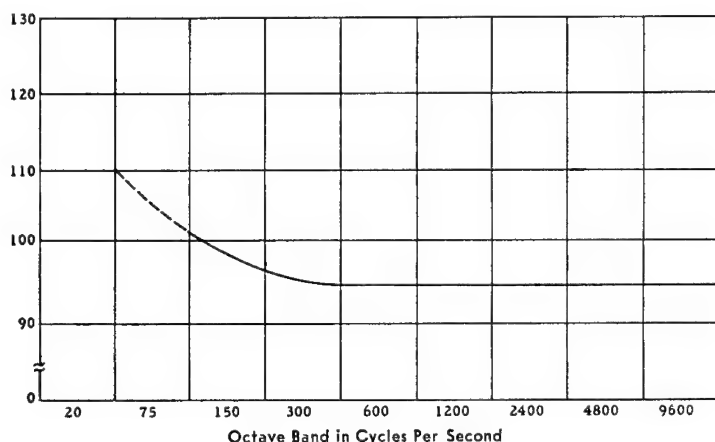


Fig. 5. Damage-risk criteria: Lifetime exposure to wide band noise eight hours per day.

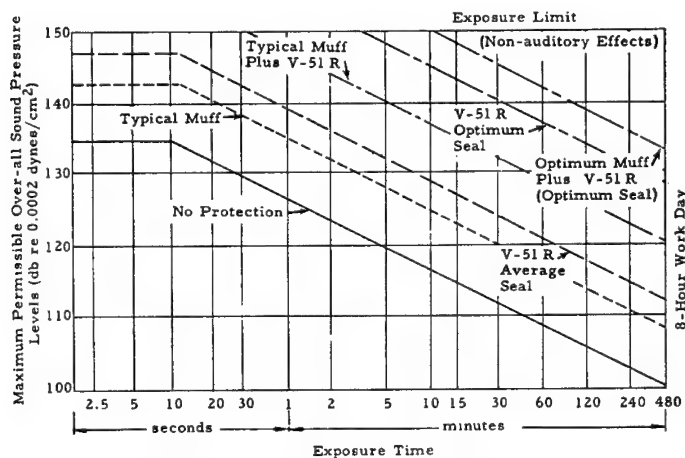


Fig. 6. Short-time exposure criteria for jet type noise. Note: The maximum permissible over-all sound pressure level of jet exhaust noise is given as a function of the average daily exposure time for the protected and unprotected ear.

posure criteria" more applicable to the problem of manned space vehicles. Their data pertain to turbojet engines which also produce wide band noise.

sure to jet noise ranging from a few seconds to eight hours.

The "no-protection" curve considers 135 db as the maximum allowable over-

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all sound pressure level for exposures up to ten seconds. The curve then decrements to allow a constant noise energy exposure with increasing time up to eight-hours duration. Consequently, the maximum permissible

cause of the extra-auditory effects encountered.

Human Tolerance to Noise, Temporary Effects.—Exposure to loud noise considerably below the previously de-

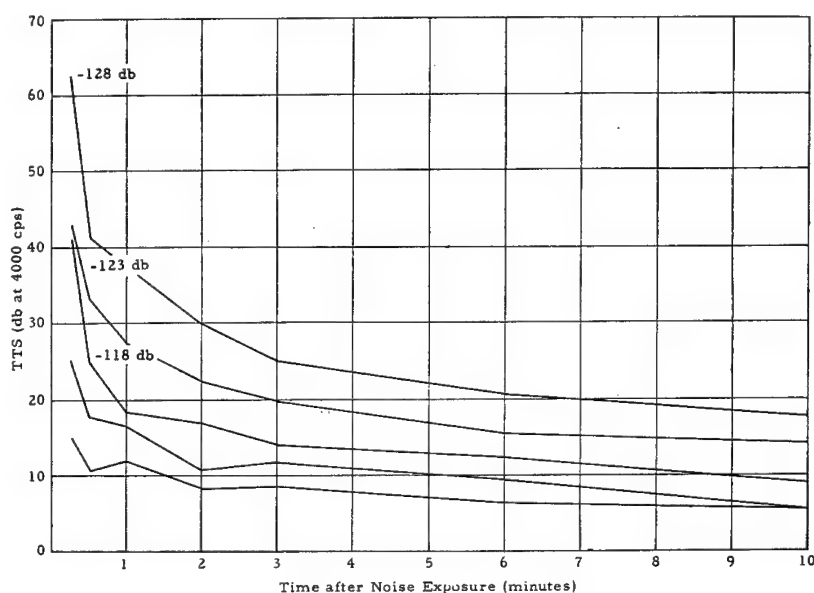


Fig. 7. The effects of three-minute exposure to wide band random noise.

over-all sound pressure level is reduced by 3 db for each doubling of the exposure time after the ten-second point. The noise level allowed for eight-hour exposure corresponds to the over-all sound pressure level given by the "damage-risk criteria" of Rosenblith and Stevens for jet noise spectra. The curves representing greater degrees of protection allow the same noise energy to reach the ear as is allowed by the "no-protection" curve.

All curves were terminated at 150 db as it is considered unwise to expose personnel to higher levels regardless of the type of ear protection worn, be-

scribed "short-time exposure criteria levels" will cause significant temporary reductions in man's auditory threshold. Two studies have been done which are pertinent to the acoustic environment in space flight.

Trittipoe¹¹ studied the effects of three-minute exposures to wide band noise on the auditory threshold of young men. Intensity levels ranging from 108 db to 128 db were studied in 5 db steps. Each subject was followed for ten minutes after the exposure by means of a Bekesky-type audiometer at 4000 and 6000 cps. Figure 7 illustrates the type of data obtained. In

general, the degree of upward shift in the auditory threshold (temporary threshold shift—TTS) increases with the intensity of the noise exposure over the tested range. These threshold shifts are transitory. However, the

most pertinent to manned space vehicle problems is the observation that when the threshold sensitivity of the human ear is depressed markedly (60 db) by exposure to high intensity noise, the loss is only 25 db for the level of aver-

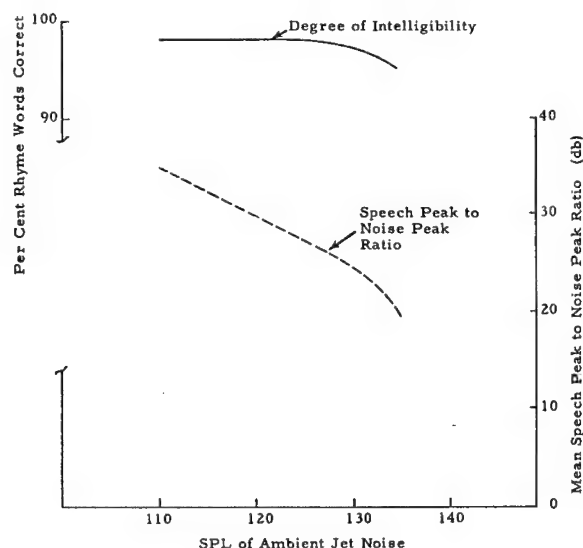


Fig. 8. The effect of noise on speech.

changes to 128 db exposures are quite significant. For example, at fifteen seconds after the exposure the TTS is 68 db above normal and at one minute it is still 38 db above normal.

Davis, et al⁴ did an extensive study of the effects of exposure to pure tones of 500, 1000, 2000, and 4000 cps and to a wide-band random noise, at intensities of 110 to 130 db, for periods of from one to sixty-four minutes. The auditory function tests used were (1) threshold sensitivity for pure tones (audiometry), (2) perception of loudness, (3) perception of pitch, and (4) ability to understand speech (Fig. 8).

The aspect of this work which is

age speech (70 db) and for loud speech (100 db) the perception of speech is nearly normal. The conclusion of Davis' group is that the TTS is a "nerve" type of deafness, which varies with the loudness-level, that is, the higher the input signal, the less the reduction in sensitivity.

A comparison of the predicted acoustic environment for space vehicles and the available data on human tolerance to noise indicates that noise will not present a health hazard if attention will be given to the design of the manned capsule with respect to its resonance characteristics. However, the operational problem of voice communications should be considered.

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Communications in High Noise Fields.—The work of Klemm and Webster⁸ indicate that adequate radio communications systems can be devel-

acceptable), 3. Automatic noise actuated volume control to conform with preferred listening levels, 4. Peak clipping of 12 db of maximum power to

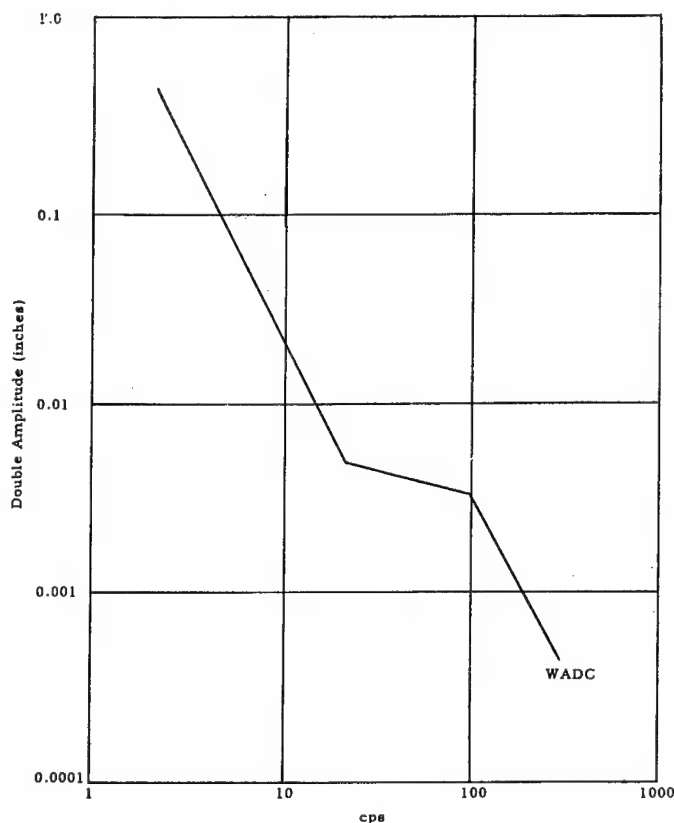


Fig. 9. Human vibration tolerance.

oped for voice communication in 135 db random noise fields. Their particular system was designed to operate on the flight decks of aircraft carriers. The pertinent design criteria for a successful system are as follows: 1. Bandwidth as wide as possible—(200 to 6100 cps desirable), 2. Side tones less than 10 db over the preferred level noise actuated (zero side tone is

earphones, 5. Flat frequency response and minimum distortion in the audio circuitry, 6. Pilot and talker training for a minimum of four hours.

Figure 8 indicates the degree of intelligibility obtainable with a system incorporating the above design criteria. The lower curve in this figure indicates the speech-peak-to-noise-peak ratio.

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VIBRATIONAL ENVIRONMENT IN A FUTURE SPACE VEHICLE

The principal sources of vibration in space vehicles are the same as for noise, that is, the propulsion system and the aerodynamic gust loads. Of these, the propulsion system is the most important. The fluctuating pressure levels generated from the rocket engine jet and combustion chamber are transmitted by air to the nose cone and by the structure acting as a filter. Vibrational energy is transmitted for the most part at the structure's resonant frequencies. These resonant frequencies depend on the missile's length, mass, and stiffness, and will usually be below 50 cps. In flight, the mass and length change as fuel is used and booster stages are discarded. Therefore, the principal vibration frequencies will also change. Accurate prediction of the vibrational characteristics of a future vehicle is nearly impossible at the present state of the art.

Human Tolerance to Vibration.—Figure 9 presents the data obtained by Getline⁶ for human tolerance to several hours exposure to vibration levels 10 times as high as shown in Figure 9. The body organs will vibrate at resonant frequencies of 5 and 10 cps. This resonance is a function of mass and dimensions.

SUMMARY

Acoustic environment can be predicted for future space vehicles with sufficient accuracy for human factor analyses.

The noise environment should not create a barrier to manned space travel.

Vibration, as limited by the structural requirements of current space vehicle design, is within human tolerance limits.

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Fatigue Effects in Radio Operators during a Program of High Intensity, Long Duration, Flying

G. MELVILL JONES, M.A., M.B., B.CH.

LONG duration flying is a strenuous occupation. Yet, although subjective observation undoubtedly reveals effects of fatigue,^{7,11} it proves difficult to find objectively measurable variables which are capable of doing so.^{1,3,8,9,10} In 1955, a controlled series of trials was conducted in which a variety of variables was chosen for objective measurement in relation to a single intensive flying program. Some of the results obtained from these trials have been reported elsewhere^{2,4,5,6} and these are summarized in the discussion below. The present account, however, is mainly confined to an investigation of fatigue effects reflected by the measurement of activity in radio operators. In long duration flights, the task of maintaining a continuous watch becomes too great for a single operator without loss of effectiveness, and the load must be spread over more than one individual. The investigations described here were designed to gain information as to the most appropriate way in which to distribute this load.

This work was conducted under the direction of the Director General Medical Services, Royal Air Force, England. The author was then serving in the Royal Air Force and is now on the external staff of the Medical Research Council of Great Britain, at the Institute of Aviation Medicine, Farnborough, Hampshire.

EXPERIMENTAL METHOD

The basic flying unit was a fifteen-hour operational sortie in a four-engine (piston) reconnaissance aircraft. Four crews were employed, each flying

TABLE I. WATCH ROTA FOR SIGNALLERS
A, B, AND C IN ONE CREW

	1st Watch	2nd Watch	3rd Watch
First sortie	A	B	C
Second sortie	B	C	A
Third sortie	C	A	B
Fourth sortie	A	B	C

four sorties over an eight-day period, one every other day. All flights occupied the same fifteen-hour period in the twenty-four-hours, take off being at 17.00 hours followed by landing at 08.00 hours the following morning. Three signallers A, B and C were selected in each crew for radio operation duties, each signaller taking a five-hour period of watch on each sortie, the position of watch within a sortie being changed in sequence according to Table I.

Measurement of signaller activity was based upon a standard hourly task comprising a series of normal operational procedures considered just sufficient to occupy a good operator for one hour in ideal conditions. Each procedure was allotted a maximum number of marks in proportion to the time

FATIGUE EFFECTS IN RADIO OPERATORS—JONES

likely to be spent upon its completion in standardized conditions. During each hour of watch, each signaller was required to complete as much of the

hour by each subject was ultimately determined from the logs by a signals officer experienced in this method of scoring, the final results being ex-

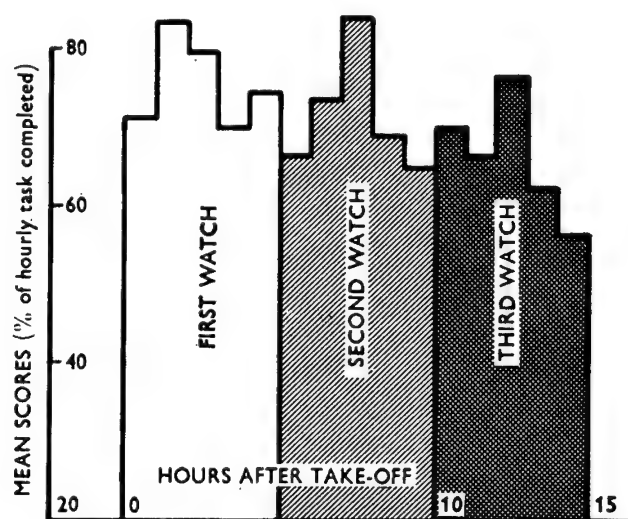


Fig. 1. Block diagram of hour by hour activity throughout the standard fifteen-hour sortie. (Each level is a mean score from the same twelve subjects.)

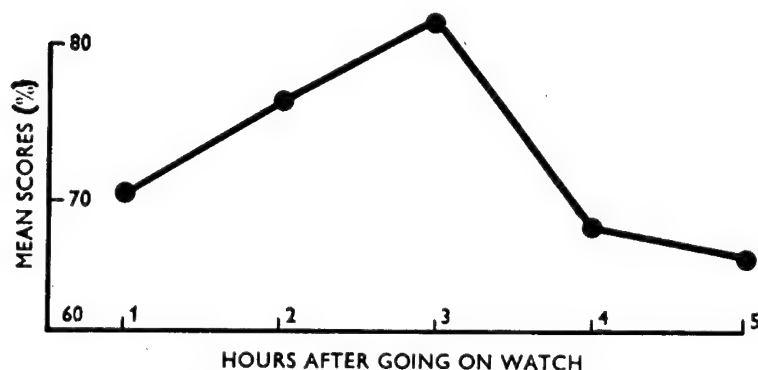


Fig. 2. Hour to hour changes during the five-hour watch.

standard task as possible and to record his achievement in a detailed log, making notes on operating conditions and serviceability where relevant. The aggregate of marks achieved in each

pressed as a percentage of the maximum hourly marks obtainable.

The experimental design permits analysis of results over three different time scales: (1) from hour to hour

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throughout a watch, (2) from watch to watch throughout a sortie, and (3) from sortie to sortie throughout the trial. In order to maintain a balanced design, only the results obtained from the first three sorties were employed in analyses 1 and 2. In analysis 3 all sorties were included.

RESULTS

The results are shown in Figures 1, 2, 3 and 4. For reasons just mentioned, the analyses of results in Figures 1, 2 and 3 are necessarily confined to the first three sorties, although in Figure 4 inclusion of all available data is permitted.

Figure 1 is a block diagram showing

been more marked the later the watch.

The results are examined in more detail in Figures 2, 3 and 4. Figure 2 gives the hour to hour changes through-

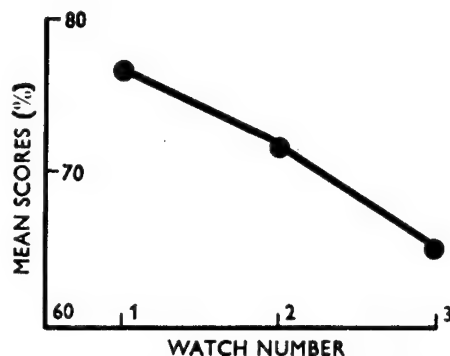


Fig. 3. Watch to watch changes during the fifteen-hour sortie.

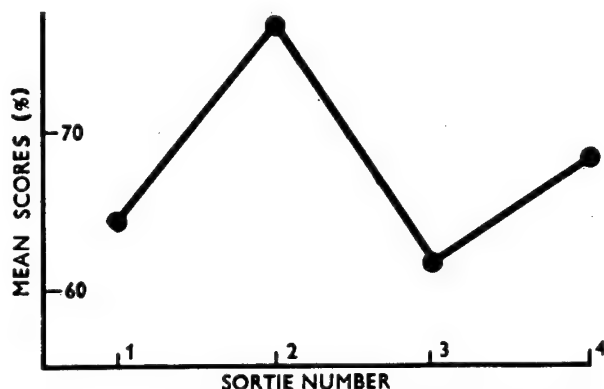


Fig. 4. Sortie to sortie changes throughout the eight-day trial.

the general pattern of activity during the standard fifteen-hour sortie in which three main trends are evident. First, optimum conditions appear to have obtained over the middle of a five-hour watch. Second, there was a tendency for the general level of activity to fall as the sortie progressed. Third, the decline in activity towards the end of a watch appears to have

out the standard five-hour watch. There was a progressive increase in activity from the first to the third hour followed by a marked fall in the fourth hour. The peak activity in the third hour and the marked fall in activity from the third to the fourth and fifth hours are both statistically significant at the 1.0 per cent level, and consequently represent real and consistent

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changes in the crews concerned. The optimum duration for a radio operator watch in these experiments was therefore three hours. This finding conforms with subjective impressions obtained from a general discussion after completion of the trial, in which the consensus of signaller's opinion was that maintenance of a good standard of work was relatively easy during the first three hours of watch, but that thereafter the effects of fatigue made it progressively more difficult to do so. One subject volunteered that he found he "couldn't care less during the fourth and fifth hours of a shift."

Figure 3 gives the watch to watch changes throughout the standard fifteen-hour sortie. A progressive decrease in activity occurred from one watch to the next throughout the sortie, the statistical significance attached to these changes being at the 5 per cent level between the first and second, and second and third watches, but at the 0.1 per cent level between the first and third. These results therefore represent real decrement throughout the sortie, a finding which was also supported by subjective opinion.

Figure 4 gives the sortie to sortie changes throughout the eight-day trial. There was increased activity on the second day followed by a fall to the initial level on the third day and partial recovery on the fourth day. In this figure, there is no obvious progressive change throughout the trial. However, a 1.0 per cent level of significance is attached to the changes shown which are therefore considered to have been real and consistent. In fact, all crews showed changes of a similar pattern except insofar as one crew, mentioned

in the discussion below, showed a marked fall in activity on the final sortie. A suggested explanation of the findings is as follows.

The low score on the first sortie was probably due to unfamiliarity with the set task; the increased activity on the second sortie was largely due to a learning factor; the subsequent decrease on the third sortie reflected a real fatigue effect (the significance attached to this change was at the 0.1 per cent level), and the partial recovery on the last sortie was due to an "end-spurt." This interpretation was supported by the opinions of radio operators, although it should be noted that crew captains were unanimous that the most harassing sortie of the four was the last one.

DISCUSSION

When the experiment is reviewed as a whole, it is evident that three largely distinct categories of experimental result are available. The first of these, summarized in Figure 2, provides information about changes occurring over a five-hour period of continuous work. This period is probably too short for the effect of lack of sleep to have significantly influenced the results, which can therefore be looked upon as reflecting decrement of a short-term nature due to the effect of the task itself. Results in the second category, summarized in Figure 3, provides information about changes occurring over a considerably longer period of continuous duty in the air, namely fifteen hours, a period which in itself exceeds the normal man's working day by roughly 50 per cent, but which, in practice, is extended to

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roughly twenty-four hours wakefulness when the associated preparation and debriefing are taken into account. The decrement incurred here, therefore, is probably a manifestation of a longer term fatigue effect attributable to the bodily and mental changes which inevitably accompany a continuous period of waking activity without rest. Bearing in mind that each point in the figure represents the activity of a signaller who, although engaged in other duties, had not previously undertaken a radio watch during the flight, it is evident that a simple change of duty was not enough to prevent decrement of this nature. This finding, therefore, recommends the introduction of effective periods of scheduled rest in flight, with the opportunity for sleep during long sorties, a recommendation supported by the fact that occasionally in the later stages of a sortie crew members were unable to prevent themselves falling asleep at their operational stations.

The third category, summarized in Figure 4, was designed to give information about cumulative effects over the longer time scale of eight days, although in the event there was no clear cut evidence of this effect having been present. It would be easy to conclude from this finding that the twenty-four period off-duty between flights was sufficient to restore signallers completely. But such a conclusion must be regarded with caution in view of the probable interference of beginning and end effects already mentioned.

Parallel investigations of pilot performance,⁴ physiological reactions to stress⁵ and vigilance² were conducted

during the same trial. Jackson investigated the performance of ten pilots by making continuous records of altitude and heading during chosen periods of manual flight. The results showed significant deterioration within a two-hour period of watch and throughout the sortie as a whole, although here too there was no reliable evidence of cumulative effects occurring from beginning to end of the trial. These results, therefore, showed substantially similar findings to those of measured activity in radio operators, except insofar as deterioration within a watch was detected over a shorter period of time. This difference is noteworthy in that it indicates variability in the rates of change which occur in different crew duties and hence emphasizes the necessity for examining these separately if the optimum durations for a continuous watch are to be determined.

Both the physiological and vigilance studies gave statistically significant evidence of changes having occurred in response to the overall stress experienced on flying days as compared with non-flying days. The analysis of vigilance also showed significant cumulative deterioration from beginning to end of the trials, a finding which confirms the advisability of treating with caution the negative findings discussed above. In this connection, it is noteworthy that despite the lack of objective evidence for cumulative effects, the progressive intrusion of less tangible factors such as irritability, lack of tolerance, loss of appetite and deterioration of qualities such as leadership, eagerness and personal drive was amply evident to observers on board the aircraft. Indeed, during the final

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sortie, one crew reached such a state of internal friction that its members had to be disbanded and re-distributed after completion of the trials. It is significant that this was the crew, referred to earlier in the description of results, in which signallers showed a marked fall in activity on the final sortie. It is relevant that the same crew (ten subjects) showed an overall loss of weight from beginning to end of the trials which was greater than any other crew at the 5 per cent level of significance.⁶

It is interesting to compare the results of this trial with those of McGrath, Wittkower and Cleghorn⁷ who studied fatigue effects during long flights in the Tokyo air lift since, although restricted to the method of subjective observation, their findings showed some striking similarities with those here reported. For example, progressive deterioration in the standard of radio operation and the accuracy with which pilots maintained a constant heading was noted. In addition, the deleterious influence of factors such as irritability, tension and loss of initiative was stressed as also was the importance of cumulative effects. It is noteworthy that in an investigation such as theirs, based upon experience rather than experiment, the interdependence of performance decrement and less tangible although perhaps equally important personality changes, is at once obvious, and comparison of the report of McGrath et al with the present account serves as a useful reminder that in this field of study the subjective approach can, in its proper place, still provide an important contribution to the results of

objective experimental observation of the kind here reported.

SUMMARY

An investigation of activity in radio operators during long-duration reconnaissance flights in piston engine aircraft is described. The basic flying unit was a fifteen-hour sortie divided into five-hour watches. The subjects were given a set hourly task, their achievement being scored as its percentage completion in each hour. The experiment was designed to allow examination of results in relation to three different time scales, namely from hour to hour within a watch, from watch to watch within a sortie and from sortie to sortie within the eight-day trial.

The optimum duration of watch for a signaller on radio operator duty in flight was found to be three-hours, a consistent reduction in measured activity, associated with subjective deterioration, becoming manifest after this time. The penalty for exceeding this duration tended to increase as the sortie progressed.

There was a progressive decrease in mean level of activity from watch to watch throughout the standard sortie, a decline which it is contended could be partially offset by introducing appropriate rest schedules during long flights.

Changes from one sortie to the next, although statistically significant, were not progressive. It is suggested the results have been masked by beginning and end effects.

Changes occurring over the three time scales mentioned, are discrete,

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and must be separately measured for useful interpretation of results.

ACKNOWLEDGMENT

The author is indebted to the Director General Medical Services, Royal Air Force, for permission to submit this work for publication. The W/T operator task was devised and scored by Squadron Leader W. J. Heeley without whose assistance these results could not have been obtained. Grateful acknowledgment is also given for assistance in statistical analysis by D. C. Gronow, and for unfailing co-operation from the aircrew concerned and those concerned with organization of the flying programme.

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The Stresses of Space Flight

Our knowledge of psychological stress in space flight is based largely on inference. For example, it seems plausible to suspect that separation from earth and prolonged exposure to danger will be serious problems for space crew members. Reactions to analogous experiences are described in accounts of shipwrecked sailors, arctic explorers, prisoners of war, and pilots of high altitude balloons or advanced test aircraft. Although stimulus deprivation and lack of drive objects arising in these situations may present a severe threat to the ego, frequent examples of effective adaptation are found. By extrapolating from these data, one may predict that space flight will impose no psychological stress which carefully selected, trained crews cannot withstand.—GEORGE E. RUFF and EDWIN Z. LEVY: Psychiatric Research in Space Medicine, *The American Journal of Psychiatry*, March 1959.

The Potential Application of Hibernation to Space Travel

RAYMOND J. HOCK, PH.D.

THE ADVENT of the space age has focused attention on problems to be encountered by the crews, particularly on journeys of several to many years' duration. In an attempt to alleviate these problems, especially that of aging during flight, several possibilities have been mentioned.

DILATION OF TIME

The first of these is that aging in space will not occur at the same rate as on earth due to the rapid velocity attained, and the dilation of time. Aside from the fact that aging is a function of the physiological processes of the body rather than of the revolutions of a clock or the turning of leaves on a calendar, this appears to be an incorrect interpretation of the physical facts of relativity. It is widely believed that the rate of passage of time decreases as the velocity of the object increases. The facts are that this is only *apparent*, and even then, only at velocities near that of light. Let us suppose an object moving rapidly away from the earth, and provided with a perfect synchronous clock with one on earth. Instantaneous viewing of this clock from earth will reveal that it *appears* to be *slower* than the clock on

earth. When the object is approaching earth, the time *appears* to be *faster* to an observer on earth. However, when a round trip is completed, the clock on the object and on earth are exactly identical.¹¹ However, it is not the time as it appears on earth that is important, but the time on the object itself. The passage of time is in relation to that object, and time will pass at the normal rate on the object. To conclude, speed has nothing to do with time in a biological sense, and aging takes place at the normal rate, either on the outward or return trip.

WHOLE BODY FREEZING

A second possibility, that of removing man from the environment by whole body freezing, has been recently discussed. This is an intriguing possibility, but the proponents of this measure were justifiedly hasty in pointing out that its potential application is in the distant future. The idea is based on work by Andjus and Smith, in which rats and hamsters had body temperatures reduced to 0° C. or just below.¹⁶ In these experiments it was found that maintenance of a colonic temperature below 0° C. for more than ninety minutes would not allow recovery and continued life if ice had formed in the tissues, and that only four hours could be tolerated if ice formation did not occur. Popovic found the period of deep hypothermia (15° C.) from which recovery could

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occur to be five and one-half hours, but repeated cooling could extend this time to eight hours.¹³ Luyet and Gehenio stress the necessity of cooling so rapid that crystallization of cell water does not occur, and gelation, or vitrification, takes place instead,¹⁰ so that tissues are not damaged. This is possible for very minute animals, a few cells thick, but to extend this method to large animals such as man poses great physical problems. To date no vertebrate animal has been completely frozen through with subsequent recovery, even including the famous Alaskan blackfish.¹⁵

HIBERNATION

Our third possibility is another method of removing man from his environment. Unlike the second possibility, however, it is a condition found in nature in some mammals, hibernation. One should not confuse the matter by considering so-called "artificial hibernation," as used to describe hypothermic anesthesia. This has no similarity to natural hibernation.⁸ Hibernation as it is found in mammals is: a periodic physiologic state in which the body temperature falls to a low level approximating the ambient temperature, and heart rate, metabolic rate, and other functions fall to correspondingly minimal levels. This is a condition in which life is maintained at a minimum rate possible for continued existence.

It is apparent that, if such a state may be achieved in man, many of the problems of concern to psychologists and physiologists anticipating the conditions of lengthy space travel will be alleviated or avoided. For example, boredom and isolation will not be prob-

lems to men in such a state, nor will there be strife among members of the crew. Weightlessness will also not affect men in this state, although some provision must be made for securing them.

However, it is principally in the matter of reduction of energy expenditure that we may expect the greatest benefit from the use of hibernation. Arctic ground squirrels in hibernation have an oxygen consumption 1/30th to 1/50th that found while they are active at the same temperature, marmots may show a reduction to 1/100th,¹ while bats may approach 1/150th of their normal energy expenditure.⁴

Just as oxygen consumption is reduced, so also is food consumption. If a bat can store enough fat to allow him to starve for one day, he can hibernate for 150 days. A major saving in space and load requirements could be effected by reducing food and oxygen supplies by utilization of hibernation for the crews.

Furthermore, it has been proposed by Rubner¹⁴ that longevity is a function of energy expenditure per unit weight, thus accounting for the longer life of large mammals as compared with small ones. We may therefore expect to find that a hibernator with its greatly reduced annual energy expenditures, will live longer than a non-hibernating mammal of the same body size, as its rate of aging is reduced.

The bat, *Myotis lucifugus*, weighs about 6 grams, which may be approximated to the 8 gram cinereus shrew, *Sorex cinereus*. We may thus expect a comparable longevity. Hamilton finds this shrew to live to fourteen to seventeen months.³ The bat has been

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reported to live to more than twenty years of age.²

The average daily energy consumption of a cinereus shrew is 1800 Cal/kg/day, while that of a non-flying brown bat is 174 Cal/kg/day.¹² However, this does not allow for hibernation and the diurnal drop in temperature and metabolism these bats exhibit. An annual energy budget for the shrew is 2628 Cal/yr, or 3500 Cal/16 months, the average length of life.

In contrast, the annual energy expenditure of the brown bat (not including flight), may be calculated to

much as the shrew in one year. Figure 1 illustrates this point. The discrepancy between the total life energy expenditure of the shrew living six-

TABLE I. ANNUAL ENERGY EXPENDITURES OF THE BROWN BAT IN VARIOUS PHASES OF ACTIVITY

Hours of Year at	Body Temperature	Metabolic Rate cal./gm./hr.	Total Calories per Bat
953	37	13.77	88.54
1620	20	1.89	18.36
604	16	1.73	6.30
604	8	0.29	10.44
657	7	0.27	10.62
4292	5	0.24	6.36
			Total 130.62 Cal.

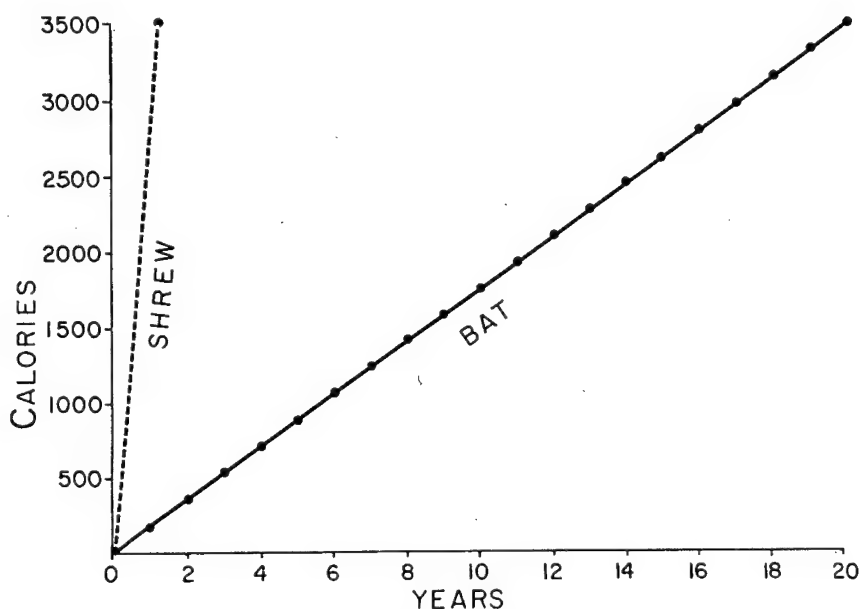


Fig. 1. Caloric consumption in the bat compared to caloric consumption of shrew.

be 130.6 Cal/yr as seen in Table I. If the bat were to spend a year at rest with body temperature of 37° C., he would consume 726 Calories, or over five times as much.⁶ In twenty years with hibernation included, the bat will consume 2600 Calories, or about as

teen months and the bat living twenty years may be due to the high metabolism of bats in flight.

Consider man as a potential hibernator. It will be necessary to radically reduce body temperature, metabolic rate, and heart rate, and thereby nearly

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all other physiologic functions, in order to achieve a condition approaching hibernation. Although men have recovered from rectal temperature of 17.8° C. (64° F.)⁹ and lower, there is general agreement that temperatures below 24° C. (75° F.) are usually lethal. In practice, 30° C. (86° F.) is used in hypothermic anesthesia, due to the onset of ventricular fibrillation below this temperature, with resultant death. Metabolic rate at this temperature is only about 50 per cent of normal, while if temperatures of 20° C. (68° F.) could be used, metabolic rate would be about 25 per cent of normal. "Extrapolation would suggest that at body temperatures between 10 and 12 degrees, the oxygen consumption would be minimal if not nil."¹⁷

The hazard of ventricular fibrillation must be avoided in attempts to reach these low levels of temperature. The hibernators have learned how to do this, and several laboratories are currently working on ways to avoid it in man. It is thus apparently man's heart that will not tolerate low levels of cooling, although other organs may be involved at lower levels.

There is an intermediate condition that is not so radical a departure from man's normal physiologic levels. It is best illustrated in the black bear,⁶ where reduction of body temperature is only about 7.0° C., to a level close to that used in hypothermic anesthesia. Recent work has shown that metabolic rate at this temperature is reduced to about 50 to 60 per cent of normal, while in man it would be a bit higher. However, the bear naturally maintains this level for periods of several weeks to several months. According to our assumption above, aging should occur

at half the normal rate during this period.

What do we need to know to produce true, deep hibernation in man? First, we must be able to lower body temperature to 10° C. (50° F.) or below without the occurrence of ventricular fibrillation. Second, we must be able to maintain men for long periods in this condition, instead of several hours to a day as at present. Third, we must understand the dynamics of energy turnover that will allow this condition to be maintained. Fourth, we must be able to arouse the man to a normal condition, perhaps periodically, in order to allow energy levels to be built up.

A program aimed at such goals must not lose sight of the fact that the mammalian hibernators have solved these problems. The basic differences that exist between hibernators and non-hibernators are of fundamental significance, especially as regards the heart and energy turnover. The periodic arousal shown by hibernators is of great importance, as it points to the fact that some physiologic processes cannot be carried out at low temperatures.⁷ In addition to these and other studies on true hibernators, studies should be carried out on those mammals such as bears which have achieved an intermediate condition more readily duplicated by man in the near future.

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The Eminent Position of Space Medicine

While the advent of a new field of science is always a notable occasion, this is especially so in the case of space medicine because, among the various fields of military medicine currently being employed to support our military forces, space medicine unquestionably ranks number one in strategic importance. At the same time it occupies an eminent position in the general field of science in regard to its current and potential for future contributions to an understanding of nature's most closely guarded secrets. This latter will accrue from space medicine's key role in enabling man to travel in space. This is not an end in itself but rather a means to an end whereby the outer reaches of the earth's atmosphere and the space beyond may be studied at first hand by scientists of all disciplines concerned with unraveling the mysteries of the universe—HARRY G. ARMSTRONG: The Origin of Space Medicine. *U. S. Armed Forces Medical Journal*, April, 1959.

Limits of Cardiovascular Normality for Flying—A Panel Discussion

LUDWIG G. LEDERER, M.D.—Moderator, with Panel Members, CAPTAIN ASHTON GRAYBIEL, MC, USN, GEORGE KIDERA, M.D., LAWRENCE E. LAMB, M.D., GEORGE W. MANNING, M.D., F. A. L. MATHEWSON, M.D., JOHN E. SMITH, M.D., and JAN H. TILLISCH, M.D.

Dr. Lederer.—This afternoon we shall try to arrive at some conclusions concerning the significance of cardiovascular findings in relation to flying. I would like for the panel to approach the questions first from the point of view of selection for flying duties and secondly from the point of view of maintenance or retention in a flying capacity of trained individuals. We will review the problem of syncope first then consider some of the electrocardiographic findings.

Dr. Tillisch, do you feel that a person who has had loss of consciousness without demonstrable evidence of cardiovascular disease should be permitted to continue flying duties in any form of military aircraft or in a civilian capacity?

Dr. Tillisch.—I take it that when you say "loss of consciousness," you mean a loss of consciousness. Certainly the single episode of loss of consciousness, I feel, would call for no more than a continued observation with perhaps more careful and more frequent examinations. When this microphone gets to Dr. Lamb, I wonder if it might not help clarify this situation a little bit if he will define just exactly what we mean when we are discussing syncope.

Dr. Lederer.—My question to Dr. Mathewson is, what is the likelihood

of an individual who has had one episode of syncope having another in flight, as compared with individuals not known to have had a previous episode of syncope?

Dr. Mathewson.—This is not an easy question to answer. If, as I imagine, Dr. Lamb will define syncope as failure of the heart to deliver sufficient blood to the brain, then I would think certainly that such vasovagal episodes should not be expected any more frequently in flight in such a person as compared to individuals that have not had syncope. I think the one episode should be disregarded.

Dr. Lederer.—Dr. Lamb, we've saved a real good one for you. How frequent would you say syncope is in a normal healthy population?

Dr. Lamb.—The best statistics that we have available would indicate that the incidence is roughly one out of five individuals, or about 20 per cent. This, I would base on Colonel Collins statistics. With a 100 per cent return on a questionnaire from a group of 300 basic airmen from Lackland, the incidence was 22.2 per cent. Medical literature states it is common. It should be added that we are not excluding individuals with previous syncope from our flying population in the military, as indicated by the Cadet Survey which statistically indicates that the chances are only one out of twenty that the incidence of previous syncope would be less than 18 per cent or

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greater than 42 per cent in our cadets. From a statistical point of view, then, in all probability over 20 per cent of our flying population have experienced such a previous episode.

Now, what do we mean by syncope? To me this term should be restricted to people who have unexplained loss of consciousness and loss of consciousness due to inadequate blood supply to the brain, either due to loss of peripheral resistance or cardiac inhibition or both. Circulatory collapse associated with acute infectious illnesses, shock or other known primary causes, should not be called syncope. The term syncope should not be confused with encephalitis as it has sometimes been reported in certain statistics. Certainly it is not an indication of brain disease in itself. One of my pet peeves is for anyone to assume that because a person has had loss of consciousness they have brain disease. This is no more logical than for me to assume that everyone that dies, dies of heart disease because his heart stops at that particular time. It is to be assumed that the brain isn't functioning if there is no blood supply to it.

Dr. Lederer.—Dr. Manning, does it make any difference at what age an episode of syncope occurred in assessing the likelihood of future episodes of unexplained loss of consciousness?

Dr. Manning.—That is a difficult question to answer. Syncope, in the young person, I am sure, occurs in at least 20 per cent, 25 per cent, and higher than that in the younger age group if one wants to include a single episode. I would feel that anyone experiencing syncope for the first time in the middle or older age group would require a fairly careful investigation. I would think it may have some definite significance, but I don't think that in a person who experienced one or two episodes in the past and is in the age group beginning air crew training any definite significance would be placed on this unless it was related to a significant

cause. I would not be too disturbed by syncope in the young group. In the older group, one would have to look carefully to see if there were an underlying reason. If there were not, I think I would place much more significance on it, than if there had been something. I think explaining to a man and training him to know what syncope is all about has a lot to do with it. We have discussed hyperventilation and the valsalva maneuver. If he understands these and we can explain loss of consciousness on this basis, he can learn not to get himself in this situation again. Then it should have no bearing on his flying.

Dr. Lederer.—Thank you, Dr. Manning. Dr. Graybiel, is it justified to assume that just because a person has had one episode of syncope he is more likely to have a subsequent episode than an individual not known to have had a previous episode of syncope?

Dr. Graybiel.—I would think that would be a reasonable assumption.

Dr. Lederer.—Dr. Smith, are there any extenuating circumstances or causes associated with loss of consciousness that would cause one to think that such an episode would be innocuous? For example—a blow on the head, shock with loss of blood, acute febrile illnesses, alcohol, et cetera.

Dr. Smith.—Yes, I would like to perhaps explain a little bit more in detail. We see this fairly frequently in civil aviation—the person who has had a syncopal attack. We have worked out many of these cases. We generally never find any cause when they are studied by conventional neurologists at the universities to which they go. I do think this. I would worry a lot more about the man who faints twice than the man who faints once.

Dr. Lederer.—Dr. Kidera, are there any programs that could be developed to decrease the likelihood of loss of

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consciousness during flight, and what has been your experience with syncope in commercial aviation?

Dr. Kidera.—Yesterday we all heard the paper that was given indicating that there was no particular test which would be of predictive value in anticipating syncope. However, in thinking of that paper, I wonder if the stimulus was sufficiently fine enough to actually screen out the potential fainter. In other words, if you hit everybody hard enough with a pile driver, they are going to fall down. Do we hit everybody with a pile driver, or should studies be conducted in a finer way, maybe by not tilting them quite as long, or maybe by varying amounts of atropine. As far as syncope in commercial aviation is concerned, it is quite a problem. I was a little impressed with the fact that we all seem to be talking of syncope as a disease entity. I have always regarded it purely as a symptom in which the diagnosis must be made if at all possible. If it is made and the condition is curable, that is, the underlying basic pathology is fixable, we fix it and the man returns to flying. When syncope is due to massive gastric hemorrhage, the diagnosis is easy. When we get to the more difficult diagnoses or impossible diagnoses, then I think, the individual in commercial aviation definitely must be grounded, and I have a case in point. We have had three cases that are grounded now for syncope of undetermined origin. They have been examined by the neurologist, cardiologist, and in one instance a very brilliant cardio-physiologist took the man and tilted him and had him puff and huff, and said he was vagotonic or gave some such diagnosis. I'm only a country doctor, I don't belong up here with these other chaps, but I grounded him in spite of the fact that the cardio-physiologist decided this man should be flying. He was grounded a year and a half later had a convulsive episode with unconsciousness. They opened his head and he had a brain tumor.

Now here was a case of unexplained syncope in a thirty-four-year-old man who died at the age of thirty-five and one-half years. He was grounded and I am very happy that we took that action. Syncope is a problem in commercial aviation. I think you heard Dr. Lamb state that it occurs perhaps in one out of five. I wonder how that figure compares with the answers we get to the question of previous syncope on our medical examination. We have had three cases reported in answer to questionnaires, but I am quite sure there are more. In one instance of syncope that I grounded not more than three months ago, the gentleman fainted in his back yard with no extenuating circumstances. This individual denied syncope and made no mention of it to anybody. His wife was the only one that knew it. When he came out for a flight about three days later and had another episode, he admitted to the first one. I am sure that had he not had the second episode we would never have heard of the first one. I think it would be impossible for anybody to tell the true incidence of syncope.

Dr. Lamb.—I think in view of Dr. Kidera's comments there is a point or two that should be mentioned. First, I don't expect that 20 per cent of the flying population have brain tumors just because they have fainted at some time. It is always dramatic to pick out one or two cases which present pathology. We know full well that people with febrile disease do have susceptibility to loss of consciousness. We know that people with aortic stenosis also have syncope, but that isn't the type of problem we are primarily concerned with. First, the question is, what about the 20 per cent of the normal population which has apparently had previous episodes of syncope from vena punctures while standing at attention, and a host of other circumstances? Secondly, there is another very real, practical point of view to this problem if you are going to develop a hard-nosed attitude and decide that all these people

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shouldn't fly; automatically, they are not going to come to you because they recognize that you are not their friend, and automatically they will conceal loss of consciousness when they should come to you for medical assistance. As a result, you miss the case that needs help or actually should be grounded. What you end up doing, then, is lowering flying safety rather than improving it. Third, as far as predictability of tests are concerned, I think it is fairly logical to assume that people who undergo enough multiple stresses will faint. Certainly I think that if you do enough to anyone you can produce syncope. The difference in a person physiologically from the time he may have had clinical syncope on one day and when you test him some other time might be quite variable. Because of this individual variability in a person from day to day, it is very difficult to pick out selective tests. This is why the number of tests which are useful in determining susceptibility is rather minimal and limited to such things as testing for a hypersensitive carotid sinus, or the person who has true susceptibility to orthostatic intolerance on standing for less than three minutes. Lastly, I would like to make one plea. Do not be moved by a few isolated cases when the big problem is roughly 20 per cent of the population rather than one or two individual cases.

Dr. Lederer.—I think Dr. Kidera wants to comment.

Dr. Kidera.—Personally, I think consulting the flight surgeon or medical director depends to a very large extent on the rapport the flight surgeon or medical director has with his pilot group. I know we all like to think that we are getting all the confidence in the world; but I am sure in many instances we are not. One of the things I feel very strongly about, and I am sure the rest of the medical directors in this group do, is that we have a very big responsibility toward our management, and toward the people we carry. Not that I am in any way minimizing yours,

but when we are charged with this, and are certificated as an airline ordered to exercise maximum safety, I don't think there is any margin for taking a chance when we are gambling with the safety of the traveling public.

Dr. Manning.—I just want to ask a question. What was the incidence of fainters in the pilot population?

Dr. Lederer.—Dr. Lamb, you made an estimate.

Dr. Lamb.—I think the best answer to this is the surveys which have been analyzed by competent statisticians, one I referred to earlier. In a non-flying population of 300 people that gave 100 per cent return of questionnaires, the incidence was 22.2 per cent. This is factual information and it can't be denied that it exists. Of fifty cadets who were questioned, fifteen of them on an anonymous questionnaire with 100 per cent return, admitted to previous episodes of syncope. Such a sampling technique as this with fifty subjects indicates we are told by statisticians, that there is a probability of only one out of twenty that the incidence of previous syncope in our cadet population is less than 18 per cent or greater than 42 per cent. I think what this really means is that loss of consciousness is a symptom as previously stressed. We just must accept the fact that many people are going to lose consciousness at some time during life.

Dr. Lederer.—Dr. Mathewson wishes to comment.

Dr. Mathewson.—I think that syncope is clearly not a problem of selection but a problem of maintenance. The things that cause syncope are things that occur to people during their flying career. A man can be in the air for ten or fifteen hours and get fatigued, he can go without his meals, he can have an infection, a gastroenteritis, and so on. These are things that precipitate syncope, and the flyer should be of a mind to consult his

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flight surgeon or his medical advisor upon these problems, and I think this is how to control syncope from a practical standpoint.

Dr. Kidera.—Isn't that syncope of determined origin? I mean, this is something you could treat, something you could fix. I am not grounding that, gentlemen, if you can identify any reason why he had an episode. In most instances you will find a reason for it. When you don't, I think you had better consider the organic diseases which may exist until clinical evaluation excludes them. Then, I think, I would permit the man to go ahead.

Dr. Lamb.—I detect a difference in vocabulary by introducing the term unexplained syncope. This may be at the root of part of the variation in opinion. We use the term unexplained syncope in referring to a person who has lost consciousness from such things as fatigue, long flight hours, ingestion of alcohol, perhaps not having had breakfast, or in essence, any cause other than an acute illness, severe pain, or loss of over 500 cc. of blood. If loss of consciousness as a rule weren't due to one of these three causes, the Air Force has, in the past, removed such persons from flying considering all other causes inadequate cause for loss of consciousness. Now, if you are going to say that these other factors are known and adequate cause for fainting, this puts an entirely different complexion on the picture.

There is one other thing I would like to say before I give this up. Anyone who wants to really do something practical about syncope could do this by a preventive program which was hinted at by Dr. Mathewson. An intelligent approach would be to check the individual out each morning as he reports to fly an aircraft just the same as the plane is checked out to take off. Obviously the plane is going to be no better than the man. I don't care in how good health the man is, if he has had long hours of fatigue, too

much alcohol, or lack of food, he is going to be more susceptible to syncope at the time he might be in flight. So the point would be if you want proper maintenance of your people check them out at the time that they appear for flight irrespective of what they may have shown in tests six months earlier.

Dr. Kidera.—I'd like to see that done, but I just wonder how an airline can operate doing that.

Dr. Lamb.—That's your problem.

Dr. Lederer.—Dr. Smith, is there anything in your history sheet of the FAA examination relating to syncope? Does the pilot have to admit to it?

Dr. Smith.—I am trying to think to see if it's on the history sheet. I don't recall anything specific. There's a place for a history, but not specifically for syncope. Now, does he have to admit to it if he has had it? Legally yes. But he sure won't in most instances. There are a lot of practical sides to this thing which we have no control over.

Dr. Lederer.—I think we'll go on to some of the questions relating to the day's activities and talk a little bit about electrocardiography. Again, I'd like to remind the panel that when you answer, please keep in mind that the question is related to selection and maintenance or grounding of air crewmen.

Dr. Tillisch, here's one for you. Is the person with a slow atrial tachycardia of approximately 100 per minute, rather than the usual more rapid tachycardia noted, a hazard in flight?

Dr. Tillisch.—To emulate Dr. Graybiel, no. I suppose the question might be brought up, is there some alteration of stroke volume that might play a part in the cerebral circulation? But actually, I think that in general we

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would accept that man, we would have a very careful evaluation to be sure that there was no organic disease causing the tachycardia.

Dr. Manning.—This is a very rare bird. What is slow atrial tachycardia?

Dr. Lederer.—Dr. Lamb, maybe you can help out here.

Dr. Lamb.—We have a number of these which were reported in our supraventricular rhythms paper and because of the time limitation for presentation, perhaps it wasn't stressed. We have several individuals in the flying population who have presented atrial tachycardia. Some of ours may be classified as repetitive atrial tachycardia or short bursts of tachycardia. The term tachycardia is used even though the rate may be as slow as 100 per minute because its baseline rate with normal sinus rhythm may be around eighty per minute or sixty-five. Thus the ectopic pacemaker causes the rate of 110, 100, or in this range. The pacemaker is definitely from an atrial focus with a change in the contour of the P-wave, so it represents a tachycardia but not the usual rapid type that we refer to as paroxysmal atrial tachycardia in the usual clinical sense.

Panel Member.—Do you mean nodal tachycardia?

Dr. Lamb.—It could be included in that sense if it's a slow tachycardia, but most of these are atrial.

Dr. Lederer.—Along that line, Dr. Kidera, you wrote a paper on a twenty-year study of airline pilots. You observed the heart rate in general was really on the bradycardia side, didn't you? Dr. Mathewson, maybe you would like to answer this one. I know you spoke for fifteen minutes on it, but—the question is, what weight should be given to T-wave changes in the electrocardiogram in the flying

population? Would you stress here the study of the civilian group that you made?

Dr. Mathewson.—Well, I rushed through fifteen minutes. It will take about an hour and a half to really get this one because it is a very complex problem. I think I can summarize by saying that as far as selection is concerned, in very young people, eighteen years of age, early twenty's, if they show primary T-wave changes that are transient, I would be inclined to ignore it. In subjects a little older in years when cardiac disease is known to occur, I would take a much more jaundiced view of it.

Dr. Lederer.—Then you feel age has a definite influence on it.

Dr. Tillisch.—Speaking of civil aviation, we are dealing perhaps with entirely different things in some respects than we are in the military aviation. Many of these questions I think perhaps should be qualified: Is the man going to fly as a private pilot? Is he going to fly as an airline pilot? There is a tremendous amount of difference on how we are going to handle the individual, and I certainly feel, justifiably, that you would look at the airline pilot that comes in with some T-wave changes in a far different light than you would the individual who is going to be a private pilot. Do you agree with that Dr. Mathewson?

Dr. Mathewson.—Yes, but there's another point that helps us. With periodic re-examinations of pilots providing a whole series of cardiograms, often from one record to another, you're not quite sure whether a change is a normal variation in the amplitude of T-waves or whether it is an indication of something which at a later date will be definitely abnormal. It has been my experience in going over serial tracings of individuals that I sometimes have had to wait until I have had two or three more before I

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could satisfy myself whether or not the change was pathologic.

I agree with you that I would be more particular about an airline transport pilot than I would with a private pilot. However, since you get T-wave changes that are due to organic disease and T-wave changes that are completely innocent—the point is to separate them.

Here economics raises its ugly head inasmuch as once we have that man and we follow him for two or three years, we have him for life unless we go to a great deal of trouble. For this reason, we must take the somewhat arbitrary stand on some of these and do the man an injustice rather than gamble on him.

Dr. Manning.—I'd like to say a word about the T-wave changes which we are discussing. From my own experience, those that occurred in individuals in the forty- forty-five, fifty age group have eventually proved to be problems of myocardial disease, but these same exact changes occur in the group of eighteen to twenty-four years, and this leaves me with no answer, really. I can't bring myself around to feeling that say 4 per cent of the population at that young age is showing manifestations of coronary disease. I can't answer my own question here as to what their significance is in the young individual.

Dr. Lederer.—Dr. Lamb, I know you have already expressed your opinion about left bundle branch block today, but if you would reconsider your answer now in the light of what I have asked the panel to do: What should we do about left bundle branch block? Should it be considered innocuous in some individuals, or how will one decide whether such an individual should or should not be engaged in flying activity?

Dr. Lamb.—I think the answer to that should be that we recognize that some people have left bundle branch

block probably from some innocuous etiology such as myocarditis from scarlet fever during childhood, but the incidence of left bundle branch block is so small, and the frequency of coronary artery disease as etiological agent is so great, that we would be taking an unnecessary risk to utilize such a person for primary control of aircraft, or as a commercial pilot. For this reason, it is my personal recommendation that anyone who has complete left bundle branch block should not be put in unrestricted flying categories, nor should he be a commercial pilot.

Dr. Smith.—I'd like to know what Dr. Lamb bases that on. I'm quite disturbed about left bundle branch block because I have a feeling by the way he presented his data that there is an element of thinking which is dangerous. Some of the reasons he gave I don't consider very good reasons for fearing left bundle branch block. Now have you got any real data on a follow-up series from which you can prove that left bundle branch block per se is dangerous?

Dr. Lamb.—Obviously we don't have long term follow-up studies since the study began in 1957. But the best data that you can have is that out of 67,375 unselected healthy flyers, it has only occurred thirteen times. I spent fifteen minutes reviewing this this morning. We evaluated ten of the cases with extensive clinical work-ups and reported what we found in each one of the ten cases. The majority did not have innocuous findings. It may depend on how you define innocuous, but certainly it leaves a great question in your mind as to whether you could ever consider left bundle branch block as congenital in origin. In addition to that we have twelve other cases whom we have seen in the flying population who had some real data which was presented today. The data demonstrated abnormal electrocardiograms in certain instances in young individuals prior to

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the development of left bundle. Now, I'll turn that question around and challenge you. What evidence do you have to prove that left bundle branch block is ever innocuous?

Dr. Smith.—Well, I don't in any numbers. I do have some cases, however, and I'd like to bring this out—I feel there is a little bit of a cult of adulation toward the electrocardiograph at this meeting, which bothers me. One case of LBBB has been flying safely for a scheduled airline seventeen years after the diagnosis was made and still has no other evidence of heart disease. If people are going to analyze electrocardiographs the way you people have done here, and do it on a research point of view, I think it's a wonderful procedure, but when you are trying to get too much specificity from the electrocardiograph someone is going to get burned. I think some cases of left bundle branch block are going to be dangerous to fly. In my experience, we have quite a few of them that we have let fly among the private group. We had some that I'm not supposed to know about, but are flying commercially, and so far we have had no difficulty. So then you say, what have I got to prove this? You presented a twenty-year follow-up on a case. You presented one case with good data and the other purely emotional, at least partly emotional—I'll put it that way—because how can you say a man has left bundle branch block, and then go back and say that this is dangerous because he had acute indigestion two years ago.*

Dr. Lamb.—I think you have misquoted me on a few things. I did not say that people were prone to die who had left bundle branch block, or that they were dangerous in that sense. I said left bundle branch block was not congenital, and that some pathological process must be present. I specifically stated that this pathology in certain instances could be innocuous.

I presented a twenty-two-year case follow-up to substantiate that claim. I also said the danger was not because I thought every man had coronary artery disease. The high incidence of atherosclerosis as an etiology was sufficient that the risk wasn't warranted. Now if you wish to take the risk, that's your responsibility. I would like to say that this is a problem you will have to solve for yourself. The Air Force has solved its problem. We know how many of our people have left bundle branch block. Any cases in the future will represent new cardiac events.

Dr. Lederer.—Dr. Manning—Let's get a fresh viewpoint here. Do you wish to comment on this?

Dr. Manning.—In going over the total of 20,000 people we've had only one example of left bundle branch block. I can't tell you whether this man had any history to account for it, but it certainly would seem a very rare finding. There may be one other that I have missed, but according to my recollection it is one in 20,000, and that one may be well explained. I cannot tell you that. I think it's most unlikely to be of congenital origin.

Dr. Smith.—Dr. Manning, I've got news for you—when you hit three of them on your desk in the same day, it isn't very rare.

Dr. Lamb.—What age, Dr. Smith?

Dr. Smith.—Well, most are young asymptomatic people as far as I know. I don't remember the ages.

Dr. Tillisch.—One of them is forty-two.

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*The case alluded to had a normal ECG at age twenty-four recorded as a diagnostic procedure for unexplained indigestion. Two years later a second ECG recorded routinely demonstrated complete left bundle branch block.

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Dr. Lederer.—I think our face is slightly red also on right bundle branch block—and that is the next question. Dr. Manning, what should we do about right bundle branch block. Should it be considered innocuous in all individuals or how will one decide whether such an individual should or should not be engaged in flying activity?

Dr. Manning.—From the standpoint of selection, we have found right bundle branch block to be a fairly common finding, and in healthy fit young individuals. I would think at this stage of the game, one could avoid a lot of difficulty by just saying we won't accept the man, that's that! Because it could lead to difficulties of many types later on even in the normal individual. We could say we won't take this man because he does have a pattern of right bundle branch block. However, we haven't followed that approach. We have accepted most of them, unless there was some evidence to suggest that he might have a congenital problem. The simplest way would be to reject the man, but we haven't done this. We have accepted them as navigators, which is not as bad as if they had control of the aircraft. From the standpoint of maintenance I feel that if right bundle branch block appears in a trained aircrew member, pilot or otherwise for the first time and hadn't been there before, even though it be an innocent pattern usually, that it's evidence of myocardial damage or disease, and I would feel that it should be looked on as having the same significance as coronary problems. This is a little difficult because we do see intermittent right bundle branch block in young men. We have a few examples of this where the man will show right bundle branch block pattern, then be recalled for a study in say a week or ten days or less, and have a normal pattern. This, I think, is an innocent finding, too. In summary, if right bundle branch block is discovered in a trained individual who has had a previous normal electrocardiogram, and it

is persistent, then I think he should be grounded.

Dr. Lederer.—Dr. Graybiel, here's one for you: What should be done with people with A-V block? Should there be a limit on how long PR intervals should be, or should it be a physiological cut-off between first and second degree A-V block, or between second and third degree A-V block?

Dr. Graybiel.—In our experience, we have only found partial heart block, or a long PR interval, in the young flyers, and I wouldn't reject anyone with this finding—if we could bring the PR interval down to an acceptable limit, through some procedure. Usually you can do it very easily by just having them stand up. I think the prolonged PR interval does tend to fluctuate a great deal throughout life. As has already been brought out, on the youngsters that we examined first in 1940, in the repeat electrocardiogram on a lot of them, this had gone. Where you see a long PR interval, if you take repeated records, you find there is a great deal of variation from one time to another. I think our opinion of the significance of this finding has changed over the years. At the same time, I don't think that we can lose sight of the fact that simply because sometimes it is of physiological origin there are other times when it is not. I think that serial electrocardiograms and special tests to determine its persistence, are all helpful in making an evaluation. I would hate to set any particular figure as being abnormal.

Dr. Lederer.—Dr. Smith, this one refers to a regulation just passed recently in your administration. What should we do about the individuals who present electrocardiograms compatible with previous myocardial infarction?

Dr. Smith.—Well, we just passed a regulation that the cases will be de-

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nied pilot's licenses, medical certification. These people are very hot politically and they have a big framework of support back of them especially in the private group, to allow certain selected cases of healed infarcts to fly. I am, you might say, sitting on the fence on this. I think that some of these, whom we could pick reasonably as a good risk group, we should allow to fly on the basis of safety alone rather than drive them underground. They are all flying now. We have no way of taking them out. We have 150,000 private pilots in this country that don't get an electrocardiogram. We have 2,000 people over sixty that don't even get an electrocardiogram so you can imagine the number of healed infarcts that are flying. You can't pick it up with a stethoscope, and so what do we do in this area? I would personally feel that were we to be a little more liberal and be allowed to choose the individual and to allow some of them to fly, we might get more support. However, no one ever seems to agree with me on this. We have passed the rule, and it is now out of my hands and everyone we pick up with an infarct, which we never do in the private group, is not allowed to fly.

Dr. Tillisch.—Dr. Smith, what would be your criteria—this one's the mild one that can fly, and this one's the severe one that cannot fly?

Dr. Smith.—Well, there have been certain laboratory criteria. This needs more research development on it, but McNeely did some selection in his statistical setup in which he felt he could pick out a good risk and a poor risk. We all must admit that the selection of a good risk or a poor risk myocardial infarction is not perfect, but how many do we have now? The electrocardiograph itself is not perfect. I know an industrial medical program with 75,000 people in which was established the number of heart attacks that occurred in this 75,000, and 85 per cent of them had a normal electrocardiogram before they had an infar-

tion. So how much good is the electrocardiogram even when we have it?

Dr. Manning.—What were those last figures?

Dr. Smith.—The industrial medical program involving 75,000 employees, in which they had a good program, in which they had yearly physicals and electrocardiograms past age forty. The people that developed myocardial infarction in that group, 85 per cent of those that developed it, had normal electrocardiograms, before they developed the infarction, *before*, not during the infarction.

Dr. Manning.—This looks difficult. You say that you have 210,000 to 150,000 men flying and the regulation is in force now that they cannot fly with an infarction, and yet no ECG can be taken on them. There is something amiss here. What are your regulations?

Dr. Smith.—We have an electrocardiograph requirement in the Federal Aviation Agency that involves only airline pilots. It does not involve commercial pilots, other than airline captains, or private pilots. Now, what good is it to put a rule in that says myocardial infarction is disqualifying. This is a philosophical approach to medicine when you can't take an electrocardiogram and you can't rely on the history. How else do you make a diagnosis?

Dr. Graybiel.—Then you think the electrocardiographic method is some good?

Dr. Smith.—I think it is some good, sure, but I don't like the aura of specificity that you get with the electrocardiograph. For instance, I've seen patients that died of acute myocardial infarction that lived for three days with a typical history and never did show an abnormal electrocardiogram. We see people all the time who apparently have severe coronary heart

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disease and who not only do have it, but develop infarction and die, and who previous to this had a normal electrocardiogram. And so, the specificity of the equipment and the technique has to be watched, I think, very carefully because I don't think it's very specific as we're trying to use it in aviation. When you get a patient with symptoms and you've got him in bed and you've got an electrocardiograph, it's a wonderful tool. When you're living 2,000 miles away from this pilot you are supposed to evaluate, it's a poor tool, and you have to be extremely conservative in the use of it.

Dr. Lederer.—Now, wasn't it your intention Dr. Smith, to study these people in clinical centers when they presented electrocardiograms such as an infarction finding?

Dr. Smith.—Right.

Dr. Lamb.—I think it should be pointed out that it is a well-known clinical fact, and I'd be surprised in this distinguished audience if it weren't well recognized, that no one really feels the electrocardiogram predicts future myocardial infarction. Anyone who has done much cardiology has probably had the unpleasant experience of recording a normal tracing, but his subject had an infarction the following day. I don't feel that that's any new gem of wisdom. This has been well recognized by the medical profession for a long time. However, occasionally the electrocardiogram is useful in detecting certain things such as atrial fibrillation which is pretty definite. Certainly, if you have evidence of previous myocardial infarction, the proper thing to do is a clinical evaluation. That is the reason why in most instances, as you will have noted from papers presented, we tried to evaluate clinically a large group of these people. You also note that the term non-specific T-wave changes is used in an effort to dispel the common implication that T-wave changes mean coronary insufficiency, ischemia or hypoxia. I think

we must remember that the electrocardiogram is rather specific for arrhythmias. In other situations that present findings which warrant further clinical investigation it is part of the total conduction. I'd like to ask Dr. Smith what he is doing about people who present electrocardiographic evidence suggestive of previous myocardial infarction?

If they don't have significant histories or physicals, just how are you approaching this problem? Are you removing people from flying status who have electrocardiographic evidence suggestive of a previous infarction as the only finding, or how do you handle that?

Dr. Smith.—Well, this is the group that has compulsory yearly tracings—the airline captain group. Now this group, when we find questionable electrocardiograms suggestive of any abnormality, we do a thorough clinical work-up, the best that we can do. In the infarction cases—usually you don't gain much more by examining the man—if you can see a rather typical infarct pattern on the ECG. You have still got the infarct to face on the electrocardiogram. We do the examination anyway, however, because I think this should go along with it. But he would be denied, and is denied at the present time, a certificate to fly commercially.

Dr. Lamb.—I interpret this then that you are disqualifying people who are asymptomatic just on the basis of the electrocardiographic diagnosis or infarction?

Dr. Smith.—Right. But I would like to add again that there is a certain uneasiness that goes with electrocardiographic interpretation as far as I'm concerned. I've done one survey of 500 normals back in 1948, taking the man in the street with no known heart trouble. Out of this group of 500 there were twelve people that had rather classical infarct tracings. When the cases were selected over thirty-five years, 3.4 per cent of these people

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were walking around that didn't have any knowledge of heart trouble, but did have classical electrocardiograms, of myocardial infarction. Of the twelve people, six had histories that were pretty good for previous infarction. They didn't know that they had it. For instance, one man had a history of epigastric pain, he was nauseated, he had diarrhea, he was so fatigued that he couldn't walk for three days, the pain was there, it was unusual perhaps. Electrocardiogram was taken six years later. Six did have some incident that you could get your teeth into, the other six didn't. The six that had some history didn't do well. I think three or four of those people, as I remember, now are dead. The other six that showed infarct patterns have had no deaths. Some of these cases are good friends of mine, and they go on living and having no trouble. It's very discouraging that twelve years later they have no symptoms. They have the same electrocardiogram. By the time I get twelve years more out of my experience I certainly must wonder, did they even have an infarction? But they had classical ECG's of infarction.

Dr. Lederer.—I think we had better move on. Dr. Kidera, I'd like to ask you a very practical question. As you note from the studies presented today, the highest incidences of abnormalities were in the T-waves and ST segments, ectopic ventricular beats, first degree A-V block, supraventricular contractions, atrial rhythm, and the wandering pacemaker, and then they dropped off. Now you've been taking electrocardiograms annually on your pilots for over twenty-two years that I know of. What have you found in people that have been flying with some of these abnormalities, and how have they done? I assume there are no infarctions or left bundle branch blocks.

Dr. Kidera.—As we go down the list, we have pilots flying with ECG abnormalities almost as you have enumerated them with the exception

of myocardial infarction. We have innumerable examples of abnormal T-waves as an isolated finding. When we do, we evaluate these individuals. I know abnormal is a bad word to use here, but we consider it an abnormal ECG until we have run them through a very careful diagnostic survey. We have established in San Francisco a cardiovascular evaluation unit in which we have a ballistocardiogram, a vectorcardiogram and an ECG. We do a Master's step test on them and also total fats and lipo proteins, and do a very thorough cardiovascular work-up. If it is an isolated finding, and no evidence of any cardiovascular disease, the individual is permitted to fly. We have had eleven cases of myocardial infarction in our pilot group, all of these, as would be expected, with previous normal ECG's. Incidentally, in none of the abnormal normals, if you will, the abnormal T-waves, wandering pacemakers, an occasional extrasystole, minimal conduction defects, did we have any of the eleven cases of myocardial infarction develop. In cases that we studied very carefully during ten to twelve years with consecutive ECG's, none of them had abnormalities prior to the infarction.

Dr. Lederer.—Time is getting short. There is one question from the floor here. I'll ask Dr. Tillisch to read it and answer it.

Dr. Tillisch.—In the re-examination of an apparently healthy commercial pilot over forty years of age, with a normal electrocardiogram before age forty, what interval would you recommend between the repeat electrocardiogram? Well, it is our habit to do this annually. I think you might say six months, you might say eighteen months or you might say three months. Inasmuch as we do our examinations annually, we feel that it is a safety factor to do it at that time.

Dr. Lederer.—Thank you. Our time has run out. I would like to say I've enjoyed this and I hope you have too.

REPORT

from the President

Aerospace Medical Association



Your president wishes to acquaint the members who were unable to attend the thirty-first annual meeting with some of the features of the sessions which I sincerely believe are very progressive strides.

Dr. Lederer announced, at the Honors Night Banquet, two new Aerospace Medical Association Annual Awards. One is the Louis H. Bauer Founder's Award for outstanding contribution to Space Medicine which is sponsored by the Eaton Laboratories Division of the Norwich Chemical Company. The second newly established award is the Harry G. Moseley Award for material contributions to flying safety. This award is sponsored by the Republic Aviation Corporation. Both awards carry an honorarium of \$500. These two awards, added to the existing Lyster, Longacre, Tuttle and Liljencrantz awards, bring additional recognition to our Association and enhance our Honors Night.

Your Association recognized the importance of Life Sciences and has created a new standing committee embracing this area.

The need for Space Medicine information has been impressive, especially for the practicing physician. Consequently, a new ad hoc committee has been established to formulate an information booklet to acquaint the medical profession with Space Medicine; in other words, "What every doctor should know about Space Medicine." This integrates well with the progress being made by the Committee on Education and Training in establishing sections in Aerospace Medicine in various medical societies at the state and local levels.

At our annual business luncheon meeting, which was the best attended to date, a new constitution and by-laws were adopted unanimously. This action provides a means of operating our Association in a most progressive manner.

The Association's Executive Offices have been expanded in order to deliver additional services to our regular and corporate members. Dr. Bill Kennard, in his capacity as Executive Vice President, will now be in a position to devote more time to the individual member requirements.

As a result of several suggestions, primarily due to the growth of our program and the expansion of our subject material, a four-day meeting is contemplated in Chicago. The membership will be kept advised regarding definitive plans, but tentatively keep April 24-27 marked on your calendar for the 1961 meeting, which will be held at the Palmer House in Chicago.

Any suggestions as to how your present officers and Executive Council can serve you will be appreciated.

G. J. KIDERA, M.D.
President

Aerospace Medical Association Awards and Elections at 1960 Meeting

Last month the May issue of AEROSPACE MEDICINE presented the thirtieth president of the Aerospace Medical Association, Dr. George J. Kidera, of Chicago, Illinois, who was installed in office in Miami Beach on May 11, 1960. Also presented were the new presidents of the three constituent associations who became members of the Executive Council for this year: Dr. Delbert F. Rey, of Palo Alto, California, president of Civil Aviation Medical Association; Dr.

William Randolph Lovelace, II, of Albuquerque, New Mexico, president of Space Medicine Branch; and Dr. Armand Henri Robert, of Paris, France, president of the Airline Medical Directors Association.

OTHER NEW OFFICERS

The Executive Council accepted the resignation of Dr. Oran W. Chenault as first vice president, and requested the nominations committee to nominate a president-

Greetings from President Eisenhower

Dear Dr. Lederer:

Please give my greetings to those attending the 31st Annual Scientific Meeting of the Aerospace Medical Association.

Throughout the history of flight there has been a strong alliance between the profession of medicine and the science of aeronautics. The program of your Association clearly demonstrates the vision and pioneering role of medical science in man's ever-expanding venture into space.

It is a pleasure to extend my best wishes for a productive meeting.

Sincerely,



Note—For members who did not get to Miami: The above message, dated April 8, 1960, at The White House, Washington, was reproduced on the inside cover of the program for the Annual Meeting.

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elect who will automatically succeed to the presidency next year. Rear Admiral James L. Holland, USN, Commanding Officer, Aviation Medical Center, U. S. Naval Air Station, Pensacola, Florida, was elected president-elect. Brigadier General Don Flickinger, USAF, Assistant for Bioastronautics and Surgeon, Headquarters Air Research and Development Command, An-

Roadman, USAF, Chief Human Factors Division, Directorate Research & Development, Department of the Air Force, Washington, D. C.

Award Winners

The announcement of the winners of the highly prized awards of the Association was made at the Honors Night Dinner by



DR. A. A. G. CORBET
Lyster Award



DR. CLARK
Longacre Award



DR. SCHAEFER
Tuttle Award



DR. HARDY
Liljencrantz Award

draws Air Force Base, Washington, was elected first vice president.

The new vice presidents of the Association are: Dr. James L. Goddard, Washington, Civil Air Surgeon and Head of the Bureau of Aviation Medicine, Federal Aviation Agency; Dr. Clark T. Randt, Washington, Director of Life Sciences of the National Aeronautics and Space Administration; Dr. G. Earle Wight, Montreal, Chief Medical Services of Canadian Pacific Air Lines, and Colonel Shigeyoshi Yamamoto, Tokyo, Japanese Air Self Defense Force. Dr. William J. Kennard was elected secretary-treasurer of the Association by the membership at the Annual Meeting, and was also elected by Executive Council to fill the newly created position of executive vice president provided for in the new Constitution adopted by the membership at this meeting.

The three members elected for a three-year term on Executive Council are: Group Captain Donald G. Nelson, RCAF, Commanding Officer of the Institute of Aviation Medicine, Toronto, Canada; Captain Joseph P. Pollard, USN, Special Assistant for Medical and Allied Sciences, Office of Naval Research, Department of the Navy, Washington, D. C., and Colonel Charles H.

Dr. George J. Kidera, chairman of the Awards Committee.

LYSTER AWARD

The Theodore C. Lyster Award was won by Air Commodore A. A. G. Corbet, Deputy Surgeon General of the Canadian Forces Medical Service. He was cited for his outstanding achievement in the general field of aviation medicine. Air Commodore Corbet received his medical degree in 1932 at McGill University. In 1940, he was squadron leader of the RCAF Medical Service, later became wing commander, then group captain, and in 1952 air commodore. In 1945 he became director of medical services at the RCAF's overseas headquarters in London, and upon his return to Canada at the end of 1945 was appointed director general of medical services at Air Force Headquarters. In 1959, he was appointed deputy surgeon general (Preventive and Environmental Medicine) of the Canadian Forces Medical Service. Dr. Corbet is a member of numerous scientific societies.

RAYMOND F. LONGACRE AWARD

The Raymond F. Longacre Award was given to Dr. Brant Clark, professor of

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psychology, head, Psychology Department, San Jose State College, San Jose, California, for his outstanding accomplishment in the psychological aspects of aviation medicine. Dr. Clark received his Doctor of Philosophy degree in 1934 from the University of Southern California and has made notable contributions in the field of aviation psychology. He served with distinction in the U. S. Naval School of Aviation Medicine and was head of the Aviation Psychology Laboratory in Pensacola in 1952-53.

ARNOLD D. TUTTLE AWARD

The Arnold D. Tuttle Award was won by Dr. Hermann J. Schaefer, head of the Biophysics Department of the U. S. Naval School of Aviation Medicine, Pensacola, Florida. He was cited for his many outstanding contributions in the field of radiobiology and cosmic radiation published regularly in *AEROSPACE MEDICINE* since 1950, and for his significant contribution toward the solution of a challenging problem in aviation medicine. Dr. Schaefer received his Doctor of Philosophy degree in 1929 from the Johann Wolfgang Goethe University in Frankfurt, Main, Germany, where he later joined the faculty as professor of physics and biophysics. He is the author of thirty-one publications in the field of bioclimatology, radiobiology and biophysics of ultra-high frequency waves and fields. Dr. Schaefer was the first one to recognize, in 1949, the microbeam effectiveness of the heavy nuclei of the primary cosmic radiation. Because of his continued studies of cosmic radiation from the theoretical and practical biological point of view involving real problems of health hazard, Dr. Schaefer's publications in *AEROSPACE MEDICINE* have been judged worthy of special recognition.

The Arnold D. Tuttle Award was presented to Dr. Schaefer by Dr. George J. Kidera, Medical Director of United Air Lines, Inc., sponsor of the award.

ERIC LILJENCRANTZ MEDAL

The Eric Liljencrantz Medal was awarded to Dr. James D. Hardy, research direc-

tor, Aviation Medical Acceleration Laboratory, Johnsville, Pennsylvania, and professor of physiology, University of Pennsylvania. Dr. Hardy received his Doctor of Philosophy degree in 1930 from Johns Hopkins University and has been extremely active in research and teaching in the fields of acceleration, measurement of pain in health and disease and in the area of fever and the regulation of body temperature. He is a well known authority in effects of acceleration on human beings and animals. Dr. Hardy served with distinction in the United States Navy in World War II. The presentation was made by Dr. George J. Kidera on behalf of Pfizer Laboratories, sponsor of the award.

NEW FELLOWS

The annual dinner meeting of the group of fellows was held at the LaGorce Country Club, Miami, May 9, 1960. The following members were elected to the fellows group: Lt. Comdr. Frank H. Austin, Jr., MC, USN, Cecil Field, Florida; Major Charles A. Berry, USAF, MC, Washington, D. C.; Captain Roland A. Bosee, MSC, USN, Philadelphia, Pennsylvania; Joseph G. Constantino, M.D., New York, New York; James D. Hardy, Ph.D., Bala-Cynwyd, Pennsylvania; Lieutenant Colonel James P. Henry, USAF, MC, Newport News, Virginia; Alfred M. Mayo, B.S., M.E., Palos Verdes Estates, California; James N. Waggoner, M.D., Los Angeles, California, and Captain Edward M. Wurzel, MC, USN, Norfolk, Virginia.

HONORARY MEMBERS

As part of the Honors Night program, President Lederer presented honorary memberships to Dr. T. Keith Glennan, administrator, National Aeronautics and Space Administration, Washington, D. C., and Dr. James A. Van Allen, of the Department of Physics, State University of Iowa, Iowa City, Iowa. The Certificate of Honorary Membership for Dr. Glennan was accepted, in his absence, by Dr. Clark T. Randt. The Certificate of Honorary Membership for Dr. Van Allen was accepted, in his absence, by Dr. William Randolph Lovelace, II.

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WIVES' WING

Mrs. Norman Lee Barr, Washington, D. C., wife of Captain Barr, MC, USN, retired, was installed as the ninth president of the Wives' Wing of the Aerospace Medical Association, at the conclusion of the Wives' Wing luncheon and business meeting. She succeeds Mrs. Kenneth L. Stratton, New York, who presided at this year's successful meeting. Mrs. Theodore C. Bedwell, Jr., Offutt Air Force Base, Nebraska, is the Wing's new first vice president, and Mrs. George J. Kidera, Riverside, Illinois, second vice president.

Mesdames D. O. Coons, Arlington, Virginia, Joseph Page Pollard, Washington, D. C., and Charles C. Gullett, Mission, Kansas, were elected board members-at-large. Mrs. Frank B. Voris, Kensington, Maryland, was chosen secretary, and Mrs. John M. Talbot, Annapolis, Maryland, treasurer.

The Wing operated its own headquarters, or hospitality room, in the Eastward Room which was open from 9:00 a.m. to 5:00 p.m. The traditional United Air Lines coffee bar, where coffee and breakfast pastry were served, was open from 9:00 a.m. to 11:00 a.m.

Dr. Ludwig G. Lederer and Dr. William J. Kennard welcomed the ladies at their annual welcoming tea and reception Monday afternoon at three o'clock, in the Westward Room. The annual business meeting and luncheon of the Wing was held on Tuesday in the Floridian Room, during the course of which a special guest, Mrs. F. O. Farrar, gave an exhibition of tropical flower arrangement. At the close of the business meeting, the past-president's pin was presented to Mrs. Kenneth L. Stratton by Mrs. Barr, the incoming president, and the honorary president charm was presented to Mrs. Ludwig G. Lederer.

RECORD NUMBER OF EXHIBITS

The number of scientific and technical exhibits at the 1960 meeting set a new record by exceeding those of any previous meeting: twenty-three scientific exhibits were set up in fifty-eight booths and forty-

nine technical exhibitors required the space of sixty-three booths. The Association and the entire membership voice their gratitude for the support and important role of the technical and scientific exhibitors at our Annual Scientific Meeting. Without them this scientific meeting as it is now conducted would not be possible.

ACKNOWLEDGMENT TO OUR SPONSORS

In connection with the 31st Annual Meeting, the Association assumes financial responsibility for the scientific program, including guest speakers, scientific exhibits, the preparation and presentation of the scientific program, and certain social events such as the International Reception for our distinguished foreign members and guests, the Honors Night Reception, and certain activities of the Association's Wives' Wing. The Aerospace Medical Association gratefully acknowledges the assistance of the many friends whose generous contributions and offers of service and facilities have been so important to the success of the 31st Annual Meeting.

Burroughs Wellcome and Company, New York, and Capital Airlines, Washington, D. C., were hosts to members and their guests at the cocktail party preceding the Honors Night Dinner. The United Air Lines, Chicago, Illinois, provided the refreshments for the Wives' Wing Hospitality Room. McDonnell Aircraft Corporation, St. Louis, Missouri, and Venti-Breather Products, Inc., Washington, D. C., sponsored the International Reception. American Airlines, Inc., New York, New York, provided the cocktails preceding the annual luncheon and business meeting. And Republic Aviation Corporation, Farmingdale, New York, furnished the portfolios at the Registration Desk.

Other sponsors who have the warm gratitude of all members include Chance Vought Aircraft Incorporated, Dallas, Texas; H. Koch and Sons, Corte Madera, California; Litton Industries, Inc., Beverly Hills, California; Scott Aviation Corporation, Lancaster, New York; Winthrop Laboratories, New York, New York, and Space Technology Laboratories, Inc., Los Angeles, California.

Aerospace Medical News

Only Designated Medical Examiners Shall Examine and Certificate All Classes of Airmen

Effective June 15, 1960, the Federal Aviation Agency will require all applicants for a student or private pilot (Class 3) medical certificate to take their medical examinations solely from designated aviation medical examiners. The Regulations of the Administrator of the Federal Aviation Agency by Amendment 13 to Part 406 of Certification Procedures as published in the Federal Register on May 6, 1960, and as reproduced below, brings to a conclusion many months of study and surveys of this problem. For additional background see July, 1959, issue of "Aerospace Medicine," pages 531-533; September, 1959, issue, pages 685 and 697; and March, 1960, issue, pages 242-245.

The regulations currently require applicants for Airline Transport Pilot (Class 1) and Commercial Pilot (Class 2) medical certificates to be examined by designated medical examiners. The change reestablishes the previous practice which required applicants for all three classes of airman medical certificates to take their medical exams only from designated medical examiners.

The regulation to require selected medical examiners to perform pilot medical examinations will enable the Agency to assure proper direction and maintain effective supervision of its aviation medical examiners. This was not possible under the existing procedure. Airmen holding Class 3 medical certificates are required to be examined every two years.

The problem of maintaining effective liaison with the entire body of physicians permitted to issue medical certificates for student and private pilot applicants was revealed in an Agency survey. It showed that of the airmen examined by non-designated examiners, 84 per cent of those who did not meet the standards were nevertheless given certificates by the examining physicians.

FAA now has approximately 2,000 designated medical examiners and over 25 per cent of the approximately 240,000 Class 3 pilots currently select doctors from this group when seeking their medical examinations. Surveys indicated that these designated examiners, with rare exceptions, are so geographically located that there is a minimum inconvenience to student and private pilots in reporting for examination. The selection of additional examiners continues and will provide even more complete geographic coverage as future needs are identified.

The Civil Air Surgeon has announced that he will welcome an application for designation from any physician who wishes to join in the Agency's efforts in support of air safety. At the same time, he pointed out that designated examiners will have responsibility for maintaining detailed knowledge of a manual of instruction, published standards, and periodic directives issued by the Agency. In addition, they must possess the equipment and facilities necessary to carry out the prescribed examinations.

Amendment 13
Eff. June 15, 1960
(25 Fed. Reg. 3946)

Class III Medical Examinations and Certificates by Medical Examiners

Notice was given in Draft Release No. 59-2 (24 F.R. 2961) that it was proposed to amend Part 406 of the regulations of the Administrator by requiring all applicants for airman medical certificates to be examined by designated medical examiners. Interested persons were afforded opportunity to submit in writing, within thirty days after publication of the notice in the *Federal Register* on April 17, 1959, such data, views, or comments as they desired. Furthermore, after issuance of a Notice of Public Hearing (24 F.R. 9847 and 25 F.R. 122) a public hearing was held on February 11, 1960, in accordance with section 4(b) of the Administrative Procedure Act.

As pointed out in the draft release, the purpose of the amendment is to reestablish the previous

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practice that only designated medical examiners may give required airman medical examinations and issue medical certificates of any class. At present, only designated medical examiners may give the examinations for and issue Class I and Class II medical certificates, but examinations for Class III medical certificates may be given, and the certificates issued, by any "competent licensed physician," whether or not he has been designated by the Administrator as a medical examiner. "Competent licensed physician" by its terms means any person who is licensed to practice any part of the healing art in the state of his residence.

The medical certificates issued to this class of airmen have become progressively less meaningful and effective. Through studies conducted by the former Medical Division of the Civil Aeronautics Administration, it had been demonstrated that many Class III airmen are being examined and medically certificated by members of the healing art who, though licensed, are not generally recognized to be properly equipped and qualified to practice aviation medicine.

There is no effective way of exercising administrative control over non-designated medical examiners and there is no assurance that failures to apply the applicable standards will be discovered and corrected. Inevitably and as a consequence thereof, numerous applicants who, in fact, are unable to meet the prescribed standards have been issued medical certificates and have been permitted to exercise the privileges of airmen. A survey has revealed that of the Class III airmen examined by non-designated physicians, 84 per cent of those who did not meet the medical standards of the Federal Aviation Agency nevertheless were given certificates by the examining physicians. In the light of the known consequence of the present policy, it appears that this is not in keeping with the intent of Congress in providing in section 314 of the Federal Aviation Act of 1958 for delegation of authority to qualified private persons to perform examinations and issue certificates.

The written views, opinions and comments from associations and private individuals and the oral presentations made at the hearing on February 11, 1960, have been carefully evaluated. Great weight was given to comments received from physicians and medical associations in deference to their professional qualifications which would permit them to assist in prescribing the most effective means by which adequate medical examinations of airmen could be conducted. The majority of individual doctors commenting approved the proposal, as did practically all the medical associations, including the American Medical Association, Aerospace Medical Association, the Flying Physicians Association, and the Civil Aviation Medical Association.

Opposition to the proposed amendment was received from the Aircraft Owners and Pilots Association, other groups, and private individuals. Their arguments appear to fall into two general categories. They contend that there is a lack of correlation between medical defects and accidents and that the proposal, if adopted, would result in great hardship and inconvenience to Class III airmen. In addition, it was charged that the family physician would, by this proposal, be barred from performing airman medical examinations. This charge is made solely by the Aircraft Owners and Pilots Association. No such concern is expressed by the American Medical Association whose membership includes almost all of the country's family physicians. On the contrary, the AMA has endorsed the plan.

Arguments which discount the significance of medical fitness in relation to flying fail to state the circumstances which make such arguments appear persuasive. No comprehensive study of such relationships in civil aviation has been made. There has been no routine medical investigation of civil aircraft accidents. It must therefore be assumed that such medical cause factors as may have been present went undetected. Support for this assumption is provided by the results of very recent investigations in which careful study has been made of the

medical aspects of accidents. Evidence of physical incapacity as the primary accident cause has been uncovered in several of these investigations. The routine application of medical techniques in future investigations should provide data which establish more clearly the extent to which medical factors constitute primary or contributing causes. The lack of statistically significant numbers of accidents known to be due to medical deficiencies is, for the above reasons, not persuasive as an argument in opposition to the practice which this amendment would re-establish. In this connection the Agency has previously announced that it does not intend to be solely responsive to disaster in determining the need for action in regulatory matters.

It is clear that the public safety is directly threatened when the pilot of an aircraft is afflicted by a condition likely to produce sudden incapacity or which interferes with his abilities to perform with safety those duties necessary in the piloting of aircraft. The threat involves occupants on the ground as well as those of the aircraft, as demonstrated by several recent light plane accidents. The unindoctrinated physician cannot be expected to appreciate fully the air safety implications of many of the medical defects ordinarily compatible with the performance of other, non-flying, types of activity. As a consequence, perfectly competent physicians have issued certificates to airmen with coronary heart disease, diabetes requiring insulin, potentially recurrent mental illness. These are conditions which medical specialists, who have carefully studied the involved safety implications, consider incompatible with safe flying. In the absence of a procedure which would permit adequate direction and supervision over the performance of examinations and issuance of medical certificates, it can be expected that airmen who do not meet the medical requirements will continue to receive certificates.

The Federal Aviation Act of 1958, enacted by Congress, directs the Administrator to investigate and determine that an airman applicant is physically able to perform the duties pertaining to the position for which an airman certificate is sought. The Administrator remains responsible for this determination even though it is made by someone else in his name. That this responsibility be satisfactorily discharged requires the Agency to be in a position to exercise administrative direction and supervision over those persons who are acting for it. As indicated above, the technical competence of examining physicians (as established by licensure) has not by itself assured the necessary responsiveness to the Agency's statutory responsibilities. The amendment adopted here is intended to assure a procedure by which the Administrator is able to provide for the necessary administrative direction and supervision in order to carry out his statutory function of properly certifying Class III airmen.

Airmen holding Class III medical certificates are required to be reexamined only each 24 calendar months. There are at present some 2,000 physicians who have been designated for the purpose of examining and issuing medical certificates to airmen. Compared to the combined overall population of licensed practitioners of the healing art, including medical doctors, osteopathic doctors, optometrists, chiropractors, naturopaths, etc., who are now authorized to examine Class III airmen, the designated examiner group is quantitatively small. This lends apparent validity to the contention of inconvenience. However, examiners now designated, and to whom all Class I and Class II airmen are required to report for examination, now examine two-thirds of all active civil pilots. In addition to examining all Class I and Class II airmen, existing designated examiners examine more than 25 per cent of active Class III airmen who voluntarily select such examiners.

Medical examiners are physicians in private practice. Examination of airmen for certificates constitutes only a small portion of their professional work. As a consequence, an increase of 50 per cent in the numbers of airmen who would be required,

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by this amendment, to be examined by designated examiners would not constitute an unmanageable addition to their workload and would, therefore, not be expected to affect the availability of an examiner's time for this purpose. Inconvenience to airman applicants would not be expected simply as a consequence of the increased number of applicants to be examined.

Concerning the accessibility of examiners by virtue of their geographic distribution, the Agency has made several comprehensive surveys within the past two years to determine the adequacy of distribution of examiners in relation to areas of general aviation activity. It is apparent that, with few exceptions, the location of examiners is such that there will be minimum inconvenience to Class III airmen in reporting to the offices of designated examiners. An accelerated program for the selection of additional examiners continues which will provide even more complete geographic coverage. Particular attention is given to areas where the need is most apparent.

The charge that family physicians would be excluded as a consequence of adoption of this amendment is false. Many family physicians have heretofore been designated as examiners. The Agency will welcome the application of any family physician who wishes to join us in our efforts to promote air safety. Examiners now designated and those who will be designated in the future will be given courses of training to ensure the most effective dissemination of up-to-date knowledge of aviation medicine concepts and procedures.

Aviation medical examiners, as representatives of the Agency, assume certain responsibilities directly related to the Agency's safety programs. They serve in their communities as the federal government's safety representative where medical matters are concerned. They have public responsibility to ensure that only those applicants physically and mentally able to perform safely are permitted to exercise the privileges of airmen.

In order to discharge properly the duties associated with these responsibilities, examiners must maintain a detailed knowledge and understanding of the subject matter of a manual of instructions, published standards, and periodic directives issued by the Agency. They must maintain familiarity with general medical knowledge applicable to aviation. In addition, they must possess the equipment and facilities necessary to carry out the prescribed examinations. This ordinarily requires that the physician acquire a minimum amount of equipment in addition to that which he would need for the ordinary practice of medicine.

Prior to designation, an examiner is required to show the extent of his medical training and experience and that he is in good standing with his local medical society. In the selection and retention of examiners, due consideration is given to the Agency's desire that its representatives be professionally qualified physicians who enjoy the fullest respect of their associates and members of the public whom they serve in the name of the Administrator.

In consideration of the foregoing, Part 406 of the regulations of the Administrator (14 CFR Part 406) is hereby amended as follows:

1. By amending § 406.1 by adding a new paragraph (e) to contain the definition of a medical examiner to read as follows:

(e) "Aviation medical examiner" shall mean a licensed physician designated by the Administrator to perform appropriate medical examinations and to issue medical certificates prescribed by the Civil Air Regulations.

2. By amending § 406.11 (b) by striking the first sentence and substituting in lieu thereof the following: "A medical examination where required will be given by an aviation medical examiner as indicated in this subpart."

3. By amending § 406.12 (a) (2) to read as follows:

(2) *Examination.* An examination for this certificate will be given by an aviation medical examiner specifically designated for this purpose. A list of these aviation medical examiners in any area may be obtained by addressing a request to the Regional Manager of the region in which the area is located.

4. By amending § 406.12 (b) (2) to read as follows:

(2) *Examination.* An examination for this certificate will be given by an aviation medical examiner. A list of the aviation medical examiners in any area may be obtained by addressing a request to the Regional Manager of the region in which the area is located.

5. By amending § 406.12 (c) (2) to read as follows:

(2) *Examination.* An examination for this certificate will be given by an aviation medical examiner. A list of the aviation medical examiners in any area may be obtained by addressing a request to the Regional Manager of the region in which the area is located.

(Secs. 313(a), 314(a), 601, 602, 72 Stat. 752, 754, 775, 776, 49 U.S.C. 1354(a), 1355(a), 1421, 1422)

This amendment shall become effective on June 15, 1960.

Issued in Washington, D. C., on May 3, 1960.

JAMES T. PYLE,
Acting Administrator.

[F.R. Doc. 60-4148; Filed, May 5, 1960; 8:52 a.m.]
(Part 406 last printed December 30, 1950)

Graduates of School of Aviation Medicine at Brooks

The primary course in Aviation Medicine, Class 60-B, which was conducted at the School of Aviation Medicine, USAF Aerospace Medical Center (ATC), Brooks Air Force Base, Texas, during the period from April 18, 1960, to June 17, 1960, had in attendance the following sixty physicians:

Allied

Lieutenant Colonel Elpidio V. Posada (Colombia); Major Syed Mahammad Akbar (Pakistan); Major Storm F. Davidsen (Norway); Major Necmettin Okcu (Turkey); Major Soejoso (Indonesia); Captain Atsushi Hata (Japan); Captain Isao Matsumoto (Japan); Captain Manuel Antonio Morales (Venezuela); Captain Theodoros Roussis (Greece); Captain Mahmood C. Safdar (Pakistan); First Lieutenants Hasan Alin (Turkey); Akbar Bayramzadeh (Iran); Min Suk Chai (Korea); Asghar Eghtedar (Iran); Mohamed A. El Bishry (UAR); Mohamed E. El Saghir (UAR);

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Sahin Kocacitak (Turkey); Amin M. Maher (UAR); Venetsanos Polimenakos (Greece); Mahamed A. Talaat (UAR); Takao Watanabe (Japan); Second Lieutenant Abdul Ahad (Afghanistan); and Second Lieutenant Ebadi Assadullah (Afghanistan).

U. S. Army

Major Edward J. O'Shaughnessy; Captain Norman K. Rinderknecht.

U. S. Air Force

Lieutenant Colonel Alfred M. Taylor; Major William J. Reals; Captains John O. Burris, William W. Cottrell, William W. Crowder, Paul H. Cummings, Phillip M. Davenport, Ralph G. DePalma, William F. Deverell, Carlton D. Everhart, John C. Fulmer, Mickey L. Gulick, Byron T. Johnson, Jr., Louis L. Keeler, Donald H. Keller, Henry Kleinberg, Frederick E. Lind, Jr., Dan C. Mills, Norman H. Moore, Jr., Richard F. O'Brien, Jr., Clyde N. Owensby, James D. Pappin, Patrick L. Pierce, Daniel W. Rader, Edward L. Ritter, Leo J. Roberts, Henry J. Schmitt, Jr., Charles G. Stoyka, Thomas M. Sweeney, Joseph M. Threadgill, Martin Trieb, Earl E. Waide, Ralph G. Wieland, Emerson K. Wirtz; First Lieutenant Ralph E. Rasor, Jr.

Naval School of Aviation Medicine Graduates

The Course in Aviation Medicine which was conducted at the Naval School of Aviation Medicine, U. S. Naval Aviation Center, at Pensacola, Florida, during the period from January 11 to June 24, 1960, had the following medical officer attendance:

Lieutenants Frederick L. Austin, Jr., USN, Gerald E. Boyd, USNR, James J. Bransfield, USNR, Ralph J. Cannard, USN, Michael F. Conmy, USNR, Milton C. Dewhirst, USN, Donald W. Ernst, USNR, Bernard H. Hirsch, USNR, George A. Jack, USN, William V. Johnson, USNR, Pierre W. Keitges, USNR, Harold E. Knuuti, USNR, Lawrence Marinelli, USN, James L. Mason, USNR, William E. Moore, USNR, James R.

Moyers, USNR, R. A. Olson, USNR, Howard W. Pettengill, Jr., USN, Stephen A. Pye, Jr., USNR, Karl J. Reckenthaler, USN, Patrick R. Robbie, USNR, William J. Siegel, USNR, Pierre E. Slightam, USNR, Bruce A. Talmade, USN, Harry J. Wander, USN, August H. Wells, USNR, and George M. Young, USNR.

Captain Graybiel Wins Admiral William S. Parsons' Award

Captain Ashton Graybiel, MC, USN, past president of Aerospace Medical Association (1957-1958), has received the Admiral William S. Parsons' Award for Scientific and Technical Progress for 1960. The award is presented each year to a Naval Medical Officer as one of the Navy League's annual awards of merit.

Dr. Graybiel, who has earned an international reputation for his work in the fields of Cardiology and Aviation Medicine, was nominated for the award by Capt. Langdon C. Newman, MC, USN, Commanding Officer, U. S. Naval School of Aviation Medicine, in recognition of his participation in recent Bio-space flights, especially his efforts as medical officer in charge of the now famous Able/Baker monkey flight.

In 1950, Dr. Graybiel was the recipient of the Association's cherished Theodore C. Lyster Award, and in 1952 he received the Legion of Merit for his work in aviation medicine. In 1954, he was president of the American College of Cardiology.

Allied Surgeons Tour USAF Medical Facilities

Major General O. K. Niess, Surgeon General, USAF, accompanied by 36 visiting allied surgeons representing 24 countries, toured Air Force Medical Service activities at Patrick and Eglin AF Bases, Florida, Randolph AFB, Texas, the USAF Aerospace Medical Center, Brooks AFB, Texas, Lackland AFB, Texas, Wright-Patterson AFB, Ohio, and medical installations in the Washington, D.C., area during the period May 12-18, 1960.

The orientation tour afforded medical

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officers from the allied countries an opportunity to become better acquainted with the latest developments in the aerospace medical sciences and to witness the latest research and training methods being pursued by the United States Air Force.

Following the tour, General and Mrs. Niess hosted the group at a reception at Bolling AFB Officers Club, Washington, D. C., on May 18.

Three Civilian Scientists Receive Special Promotion

Three high-ranking civilian scientists at the Aerospace Medical Center, Brooks Air Force Base, Texas, have been given special promotions by the Secretary of the Air Force under Public Law 313. Dr. Hubertus Strughold, Dr. Roland B. Mitchell, and Dr. Hans G. Clamann, previously GS-15's, were informed of the promotions by Major General Otis O. Benson, Jr., Commander of the Center.

Dr. Strughold, German-born, is often called the "Father of Space Medicine." He holds both M.D. and Ph.D. degrees. He joined the staff of the School of Aviation Medicine in 1947, and is presently serving as Advisor for Research at the Aerospace Medical Center. In 1958 he received the John J. Jeffries Award for his outstanding contributions to space and aviation medicine research.

Dr. Mitchell received his Ph.D. degree in bacteriology from the University of Texas in 1939. In 1948 he came to the School of Aviation Medicine as Chief of the Department of Radiology. In September, 1957, he was appointed to his present position of Chief, Medical Sciences Division. Dr. Mitchell is a Fellow of the American Academy of Microbiology and also a Fellow of the American Public Health Association. He has published approximately 200 scientific papers on aerobiology, epidemiology, laboratory methodology, and astromicrobiology.

Dr. Clamann, also German-born, is Chief of the Department of Space Medicine. He received his M.D. from the University of Heidelberg in 1928. In 1947 he joined the School's Department of Physiology-Biophysics, where he carried out studies on ex-

plosive decompression, exposure at altitudes above 50,000 feet, and the recording of gases in the sealed cabin. He has published over 30 papers on physiology and aviation medicine. He assumed duties as Chief of the Space Medicine Department in January of this year.

Coming Events

August 16-20, 1960—XIth Annual Congress of IAF, Stockholm, Sweden. Address of the secretariat: IAF-60, Box 5045, Stockholm 5, Sweden.

August 18-19, 1960—Second International Symposium on Submarine and Space Medicine, The Laboratory of Aviation and Naval Medicine, Department of Physiology, Faculty of Medicine, Karolinska Institutet, Stockholm, Sweden. H. Bjurstedt, M.D., director.

August 29-September 2, 1960—Fifth European Congress of Aviation Medicine, London. Secretary General of the meeting: Dr. A. Buchanan Barbour, Medical Director of British European Airways, Central Medical Clinic, London Airport (N), Middlesex, England.

August 31-September 2, 1960—Armed Forces-NRC Committee on Bioastronautics, Woods Hole, Massachusetts, meeting of entire Committee. Dr. Otto Schmitt, Chairman.

September 15-22, 1960—XIVth General Assembly of The World Medical Association, Berlin Congress Hall, West Berlin, Germany. Dr. Louis H. Bauer, Secretary General, 10 Columbus Circle, New York 19, N. Y.

October 24-25-26, 1960—Southwest Research Institute Symposium on the Medical and Biological Aspects of the Energies of Space, Hilton Hotel, San Antonio, Texas. Jack Harmon, Symposium Coordinator, Southwest Research Institute, P.O. Box 2296, San Antonio 6, Texas.

News of Members

Several members of the Aerospace Medical Association were among the prominent speakers in the field of aviation medicine, at the Army-Wide Aeromedical Symposium held at the San Carlos Hotel, Pensacola, Florida, June 7, 8, and 9: **Neil D. Warren**, Ph.D., Aviation Psychologist, University of Southern California, presented a paper on "Psychological Problems in Modern Aviation"; **Charles I. Barron**, M.D., Medical Director, Lockheed Aircraft Corporation, on "Medical Aspects of Aircraft Accidents Investigation"; Colonel **John P. Stapp**, USAF, Chief, Aerospace Medical Laboratory, Wright Air Development Center, "Human Tolerance to G Forces in Aircraft Accidents"; Captain **E. M. Wurzel**, USN, Chief, Aeromedical Division, Naval Aviation Safety Center, "Naval Flight Surgeon Program: Contribution of Navy Flight Surgeons to Accident Prevention"; Lt. Colonel **R. B. Austin**, USA, Chief, Aviation Branch, Office of the Surgeon General, Department of the Army, "The Assignment and Utilization of Army Aviation Medical Officers"; and Colonel **Frank Townsend**, USAF, Director, Armed Forces Institute of Pathology, "Importance of Pathology and Autopsy in Aviation Accidents." . . . Colonel **Earl F. Harris**, USAF, has retired from the Service, and is now living in Fayette City, Pennsylvania. . . . Lt. Colonel **Stanley H. Bear**, USAF, has a new overseas assignment on the staff of the USAF Hospital Wiesbaden. . . . **Jonas H. Stewart, Jr.**, M.D., has transferred from the McGuire VA Hospital in Richmond to the Washington Hospital Center in Washington, D. C. . . . Captain **Merrill H. Goodwin**, USN, is now Assistant Chief for Aviation Medicine at the Bureau of Medicine and Surgery, Department of the Navy, Washington. . . . Squadron Leader **W. J. Bishop** has a new assignment: he is Commanding Officer of the RAAF School of Aviation Medicine, Pt. Cook, Victoria, Australia. . . . **Stuart H. Shippey, Jr.**, M.D., has returned from overseas and is now on the staff of the Grady Memorial Hospital in Atlanta, Georgia. . . . **E. Tallat-Kelpsa**, M.D.,

has moved to Chicago, Illinois. . . . **James Roman**, M.D., has moved to San Antonio, Texas. . . . Major General **William H. Powell, Jr.**, formerly Deputy Surgeon General, Headquarters USAF, has retired from the Service and is now living in Alexandria, Virginia. . . . **Willard C. Baker**, M.D., has moved from Williamsville, New York, to Sanibel, Florida. . . . Lieutenant **John A. Ungersma**, NSAM, Pensacola, has been assigned to MCAF, Okinawa. . . . Colonel **Frederick C. Kelly**, USAF, has retired from the Service. . . . Captain **Anthony P. Rush**, USN, Head, Aviation Medicine Safety and Flight Training Branch, Bureau of Medicine and Surgery, **Clinton H. Maag**, Ph.D., from the Office of Naval Research, and Lieutenant Commander **Victor A. Prather**, USN, were among the nine scientists assigned as consultants for the survey (Project RAM) conducted recently by the Office of Naval Research and the Naval Medical Research Institute. . . . Captain **Edward A. Anderson**, USN, Senior Medical Officer at the U. S. Naval Air Station, Quonset Point, R. I., received a letter of appreciation from the Foreign Service of the U. S., American Embassy at Khartoum and another from the Ministry of Health, the Republic of Sudan, for his aid in the inoculations of thousands of persons against Yellow Fever on his visit to Khartoum, Sudan, during January and February. . . . Captain **Howard W. Hill**, USN, has returned from his assignment on the USS Bennington and is now going on to the Naval Air Station at Floyd Bennett Field. . . . Captain **Sidney F. Johnston**, USN, has completed his assignment at the Naval Air Station at Floyd Bennett Field, and has taken on his new assignment at NAS, Quonset Point. . . . Lieutenant **Richard H. Hedenstrom**, USNR, has been reassigned from Helicopter Anti-Submarine Squadron 9 to Carrier Anti-Submarine Air Group 60. . . . Prof. Dr. Med. **Heinz von Diringshofen**, of Frankfurt, Germany, was elected leader of the Human-Factor Group of the (German) Committee for radio detecting and ranging. . . . **Modesto M. Garay**, M.D., who completed

NEWS OF MEMBERS

the Primary Course in Aviation Medicine at the School of Aviation Medicine on 8 April, 1960, is the first Guatemalan physician to attain this honor. . . . Colonel **Hamilton B. Webb**, USAF, has been appointed Director of Medical Operations of the Aerospace Medical Center, Brooks AFB, Texas. . . . Lt. Colonel **Hugh W. Randel** has replaced Colonel Webb as Chief, Aviation Medicine Division, School of Aviation Medicine, Brooks AFB, Texas. . . . Colonel **Edgard Evrard**, Chief Medical Officer of the Belgian Air Force, was recently promoted to the grade of full Colonel.

New Members

HALL W. AGNEW, Captain, USA
ROBERT M. ALLMAN, Captain, USAF

KENNETH N. BEERS, Captain, USAF
KLAUS F. BEYER, Captain, USAF
ALBERT BOLES, M.D., Oakland, Calif.
FREDERICK P. BORNSTEIN, M.D., El Paso, Texas

CHARLES A. CAMPBELL, M.D., Sunnyvale, Calif.
JOSEPH E. CAMPBELL, M.D., Chicago, Illinois
ROBERT V. CARTER, M.D., Tarzana, Calif.
WILLIAM B. CLARK, JR., M.D., Jeffersonville, Ind.
RAYMOND M. COLE, Captain, USAF
GEORGE E. COOPER, Moffett Field, Calif.
ALLEN S. CROSS, M.D., Washington, D. C.
JAMES F. CULVER, Major, USAF

HAROLD W. DIETZ, Captain, USAF
FRANK DiTRAGLIA, M.D., Alexandria, Va.

DONALD W. ERNST, Lieutenant, USNR

THOMAS M. FRASER, Squadron Leader, RCAF

MODESTO M. GARAY, M.D., Guatemala City, C. A.
HARVEY M. GILLERMAN, St. Louis, Missouri
GEORGE W. GOLDTHORPE, M.D., Pensacola, Fla.
CECIL H. GRIMES, Ft. Rucker, Alabama

WOLF-ULRICH J. HEBENSTREIT, Seattle, Washington

JUNE, 1960

JEFF A. HODGES, Captain, USAF
THEODORE G. HOSTETLER, Captain, USAF
JOHN W. HUNEKE, Lieutenant, USN

STANISLAUS H. JAROS, M.D., Harlingen, Texas

DAVID R. JONES, Captain, USAF
JOEL JUDOVICH, Philadelphia, Pa.

JAMES N. KAUFMAN, Captain, USA
JOHN W. KING, Captain, USAF
LAWRENCE H. KROHN, M.D., Detroit, Mich.

CHARLES P. LARSON, M.D., Tacoma, Wash.
MERLE LAWRENCE, Ph.D., Ann Arbor, Mich.
WOLFGANG G. LINNENBACH, M.D., San Francisco, Calif.
THOMAS F. LOMANGINO, Chicago, Illinois
LEO LOWBEER, M.D., Tulsa, Oklahoma

D. C. McNUTT, Surgeon Lt. Cdr., BRN
ANDREW C. MONEY, Captain, USAF

EUGENE T. O'BRIEN, Captain, USAF

FELIX R. PORTELLI, Captain, USAF

DR. LUIS DE LA SERNA, Madrid, Spain
FRANK E. SOHLER, JR., M.D., Sunnyvale, Calif.
EMIL SPEZIA, Dothan, Alabama
FRANCIS R. SPINELLI, JR., Captain, USAF
SEYMOUR N. STEIN, M.D., Bethesda, Maryland
KENNETH SUGIOKA, M.D., Chapel Hill, North Carolina

MILTON TURNER, M.D., Austin, Texas

JOHN A. UNGERSMA, Lieutenant, USN

ARTHUR E. WENTZ, M.D., Washington, D. C.
TRACY W. WORLEY, JR., Major, USAF

GEORGE M. YOUNG, Lieutenant, USN

V. RICHARD ZARLING, M.D., Minneapolis, Minn.
EDWARD S. ZAWADZKI, M.D., Detroit, Mich.

Aerospace Medical Association

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The Garrett Corporation
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United Air Lines
United States Aviation Underwriters, Inc.
United States Steel Corporation

West Chemical Products, Inc.
Wyeth Laboratories

Aerospace Medicine

Abstracts of Current Literature

Prepared under the Direction of ARNOLD J. JACOBUS, Ph.D.

History and General Aspects of Aviation and Space Medicine and Biology

264. **Naval Medicine: A Decade of Progress.** B. W. Hogan. *U. S. Armed Forces M. J.*, 11 (1): 15-26, Jan. 1960.

This review of selected areas of research and development includes thermal stress, tissue transplantation, radioisotope studies, blood storage, respiratory physiology, aviation psychology (as related to selection, training, motivation, and morale), acceleration stresses, protective equipment such as

full-pressure omni-environmental suits, and restraint apparatus.

265. **Medicine in the Aerospace Age.** O. K. Niess. *U. S. Armed Forces M. J.*, 11 (1): 27-37, Jan. 1960.

The general state of aviation medicine is reviewed as to purpose, historical development, and present facilities and operations. The importance of the practical medical care of airmen as the primary function of the medical service is emphasized.

Aviation and Space Physiology

General

266. **Effects of Position on Expiratory Reserve Volume of the Lungs.** A. B. Craig. *J. Appl. Physiol.*, 15 (1): 59-61, Jan. 1960.

The expiratory reserve volume (ERV) reflects the resting position of the lungs and thorax and is the most variable subdivision of the lung volume. It was confirmed that the ERV decreased when the subject changed from the sitting to the supine position. When the subject's elbows were supported on the arms of the chair, the ERV increased 3.1% and a further increase was noted when the subject leaned forward in the sitting position. The maximal ERV was

recorded in the hands-knee position. To explain these changes the effect of the weight of the shoulder girdle and of the abdominal contents must be considered. There may also be other effective elastic forces in the abdomen in addition to those elastic forces contributed by the lungs and thorax. (Author's abstract.)

267. **Early Effect of Moderate Altitude Stress on Plasma Potassium in the Dog.** A. J. Gold, J. Q. Barry, and F. P. Ferguson. *J. Appl. Physiol.*, 15 (1): 37-39, Jan. 1960.

Exposure of dogs to a simulated altitude of 30,000 feet for thirty minutes resulted in marked respiratory alkalosis and hypokalemia. The data failed to demonstrate, however, the appearance of the early transient hyperkalemic response which has been observed in human beings in the early moments of hyperventilation. Blood pH rose from an initial level of 7.46 to 7.71 after three and one-half minutes of exposure to altitude.

From the Bibliography Section, Science and Technology Division, Library of Congress, Washington, D. C. Dr. Jacobus is senior editor of *Aviation Medicine: An Annotated Bibliography, Vol. II (1953 Literature)*, a current publication of the Aerospace Medical Association.

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At thirty minutes it had declined slightly from this maximal level to 7.63, suggesting the development of partial compensation to respiratory alkalosis. The results also indicated a temporal potassium-glucose relationship, potassium decreasing and glucose increasing simultaneously during exposure to altitude. (Authors' abstract.)

268. Hygienic Assessment of the Vibration Factor on the MI-4 Helicopter (K voprosu o gigenicheskoi otsenke vibratsionnogo faktora vertoleta MI-4). N. N. Gurovskii. *Gigiena i Sanitariia* (Moskva), 24 (3): 27-33, Mar. 1959. (In Russian, with English summary.)

The physiologic effects on animal and human subjects of vibrations (45 cps. at an amplitude of 0.3 mm. for one hour) approaching the highest frequency limits for helicopter vibrations were investigated. Initial exposure to such vibrations produced considerable changes in conditioned motor reflexes of white rats and in conditioned defense reflexes of dogs. Alterations in conditioned reflexes and lengthening of reaction times were observed in airmen exposed to vibrations on the laboratory stand and during flight in the MI-4 helicopter. It was concluded that initial vibratory stimuli evoke a spread of inhibitory processes through the central nervous system of both man and animals. However, adaptation took place quite rapidly upon repeated exposure to such stimuli in all subjects studied. It appears that vibration disturbs the excitatory-inhibitory equilibrium in the cerebral cortex, thus enhancing the inhibitory processes of the orientating reaction-external inhibition type. The rapid and stable appearance of adaptation to vibration in the human organism indicates that vibrations of the order found in MI-4 helicopters are permissible.

269. The Meteorologic Influence Upon the Physical Efficiency Index (Meteorologische invloeden op de physical efficiency index). R. J. Hamburger. *Aeromedica acta* (Soesterberg, Netherlands), 6:191-194, 1958. (In Dutch.)

A group of 704 pilot candidates were observed in their reactions to a variety of meteorologic conditions (hot and humid, sunny and humid, low air pressure, fluctuat-

ing air pressures, cold and hot front passages, etc.). The following correlations between meteorologic conditions and Physical Efficiency Index (P.E.I.) were observed: (1) Cold front passages brought about significant deviations of the P.E.I. These deviations could be positive or negative, which is in agreement with the theory that biotropic factors exert their influence upon the vegetative lability in general rather than in any specific direction. (2) The distribution of the P.E.I. values on days with varying meteorologic characteristics does not differ significantly from the expected ones. (3) The number of electromagnetic impulses in the atmosphere (wavelengths 6-100 km, frequency 3000-50,000 kc.p.s.) shows no clear correlation with the P.E.I. However, on days with high indices the impulses were lower than expected and vice versa.

270. The Effects of Sleep Loss on Component Movements of Human Motion. S. J. Harris. *J. Appl. Psychol.*, 44 (1): 50-55, Feb. 1960.

An experiment was conducted to determine the effects of 60 hr. of sleeplessness on various neuromuscular and perceptual performances. Nineteen male subjects were tested during a five-day training period, a three-day sleep loss period, and a two-day recovery period. Manipulative and travel movements in a panel control test, bimanual and unimanual coordination, and leg movement were tested according to duration required for performance. Steadiness and critical flicker frequency were also tested. Results obtained show that loss of sleep produced a differential effect on manipulation and travel movements in the panel control task. While the duration of travel movements increased, the duration of manipulation movements decreased (presumably through increased motivation). Speed of performance in the bimanual and unimanual coordination tasks and in leg movement was decreased. An irregular change was noted during the sleep loss period in the test of hand steadiness. A significant decrease in critical flicker frequency was noted. The data on travel movements and coordination tasks showed consistent diurnal variation during the sleep loss period, indicating that

this type of movement is influenced by normal psychophysiologic variations as well as by the more extreme stress conditions produced by sleep loss.

Respiration

271. Effect of Breathing O₂ at One Atmosphere on O₂ Consumption of Rats. G. Froese. *J. Appl. Physiol.*, 15 (1): 53-58, Jan. 1960.

The oxygen consumption of rats enclosed in containers, which were submerged in a temperature-controlled water bath and filled with an atmosphere of pure oxygen or air, was measured. At container temperatures of 30°, 14.6°, 25°, and 6° C., no significant difference in oxygen consumption regardless whether air or oxygen was breathed. At 20° C., oxygen consumption was found to be slightly higher during oxygen respiration. In a second series of experiments, with cage temperatures of 18° and 27° C., no significant difference was observed.

The effect of negative pressure breathing on sodium, total solute, and water excretion was observed in hydropenic normotensive, hydropenic hypertensive, and normotensive subjects, who had been pre-hydrated by water loading eight to nine hours prior to the experiment. Normotensive and hypertensive subjects responded to negative pressure breathing with an increased urine flow primarily because of increased free water clearance. Significant increases in sodium excretion did not occur. In prehydrated subjects a substantial increase in free water clearance was demonstrated, although at the time of negative pressure breathing the subjects were in an antidiuretic state as compared to hydropenic nonprehydrated subjects. The small increase in sodium excretion can be explained by dead space error. It is concluded that negative pressure breathing is not a stimulus leading to excessive natriuresis in hypertensive and prehydrated subjects, who are otherwise predisposed to natriuresis. (From the authors' summary and conclusions.)

Blood and Circulatory System

273. Effect of "Unilateral Hypoxia" on Pulmonary Blood Flow Distribution in Normal Subjects. J. G. Defares, G. Lundin, M. Arborelius, R. Stromblad, and L. Svanberg. *J. Appl. Physiol.*, 15 (1): 169-174, Jan. 1960.

The effect of unilateral hypoxia on blood flow distribution over both lungs in normal subjects was studied. In accordance with the Fick principle, the CO₂ content of the vena pulmonalis of each lung was obtained by the insertion into the bypass of the Rahn end-tidal sampler of a tonometer filled with venous blood from the subject studied. The tonometer was thus flushed with alveolar air. The CO₂ content of this blood was assumed to represent the end-capillary CO₂ content. The subject, premedicated and in a supine position, breathed 10 per cent oxygen with his right lung and room air with his left lung through demand valves. CO₂ output was measured by collecting the expired air in Douglas bags and adding to the figure obtained the volume of CO₂ escaping through the bypass. A cardiac output of between 8.5 and 4.5 l./min. was assumed. The CO₂ out-

272. Negative Pressure Respiration, Water Diuresis and Natriuresis in Normotensive, Hypertensive and Prehydrated Normotensive Subjects. W. H. Hulet and Homer W. Smith. *J. Clin. Invest.*, 38 (11): 1972-1980, Nov. 1959.

put for each lung to the difference in CO₂ content between the venae pulmonales of both lungs was then compared with the corresponding ratio from the other lung, and a per cent of total flow through each lung derived. In healthy male subjects, a change from the normal 54 per cent flow ratio for the right lung was found to be reduced under hypoxia to an average of 30 per cent. Results were subjected to a thorough discussion of errors, using Gaussian analysis.

274. Hematological Changes During Muscular Activity and Recovery. R. De Lanne, J. R. Barnes, and L. Brouha. *J. Appl. Physiol.*, 15 (1): 31-36, Jan. 1960.

Hematological changes were studied in men and women during exercise and recovery in a room-temperature, warm-dry, or warm-humid environment. An erythrocytosis due to hemoconcentration was observed which was not followed by hemodilution and was not accompanied by the destruction or generation of red cells. Hemoconcentration was influenced by exercise, but not by thermal stress, in spite of greater water losses in warm environments. Sex differences at rest were found for red and white cells, but the pattern of the reactions to exercise was similar for both sexes. Leucocytosis resulted from exercise and heat exposure, with a greater effect of exercise in the females. This is due to increased capillary circulation, hemoconcentration and lymphatic pressure, but not to the stimulation of leucopoietic centers. Changes in the systemic circulation followed by an increase of lymph flow explain the lymphocytosis. Granulocytosis occurs later, persists longer, and may be related to the concentration of circulating corticosteroid hormones. (Authors' abstract, modified.)

275. Circulation Regulation and Shifting in Hypoxia. P. Gömöri and L. Takács. *Am. Heart J.*, 59 (2): 161-165, Feb. 1960.

Two groups of hypoxic states are discussed: (1) the condition in which increase in cardiac output may result in "hypervolemic" hypoxia, and (2) the decrease in circulatory blood flow or volume which leads to "hypovolemic" hypoxia. Included in the first group are arterial hypoxia (anoxic

anoxia), occurring at high altitudes and in certain diseases of the chest such as chronic emphysema complicated by pneumonia or bronchitis; anemic hypoxia; and hypoxia due to extreme muscle activity. In such cases the cardiac output is increased, and the total peripheral resistance of the circulation is diminished. Coronary and cerebral blood supply is increased by a shift in blood flow. "Hypovolemic" hypoxia occurs in conditions of shock, hemorrhage, dehydration, and in certain cases of extreme heart failure. A slowing of circulation, leading to an increase in arteriovenous oxygen difference, a decrease in cardiac output, and increase in total peripheral resistance are typical of this group. As in hypervolemic hypoxia, a shift in blood supply to the cerebral and coronary centers occurs as a result of their relatively low resistance. In both groups of hypoxia a shift in blood flow away from the kidneys is noted.

277. The Influence of High Altitudes on the Electrical Activity of the Heart. I. Electrocardiographic and Vectorcardiographic Observations in the Newborn, Infants, and Children. D. Peñaloza, R.

Gamboa, J. Dyer, M. Echevarría, and E. Marticorena. *Am. Heart J.*, 59 (1):111-128, Jan. 1960.

Electrocardiographic and vectorcardiographic studies in normal infants and children (ranging from newborn to 14 years of age) at sea level and in Morococha, Peru (14,900 feet above sea level) demonstrated: 1. similar characteristics in newborn at sea level and at high altitudes. Definite differences were noted, however, within several weeks. 2. At high altitudes, an accentuated right AQRS (mean spatial QRS vector) deviation persists during infancy and childhood, indicating a marked delay in the evolutionary pattern of the ventricular activation process, and an increase in the magnitude of terminal QRS vectors. 3. At high altitudes, after the first weeks or months of life, the T loop shifts to a forward position and the T wave becomes positive in the right precordial leads. These characteristics remain throughout infancy and childhood. 4. Normal children at high altitudes exhibit a moderate degree of right ventricular hyper-

trophy. This is probably related to anatomic and functional changes occurring in the pulmonary circulation as a consequence of acclimatization. (Sixty-two references.)

278. Hematological Values in Healthy Men and Women Living in Arequipa (Valores hematológicos en hombres y mujeres sanos residentes en Arequipa.) M. Torres Portugal and E. Campos Valcárcel. *Anales de la facultad de medicina, Universidad nacional mayor de San Marcos de Lima* (Peru), 41 (1): 38-61, 1959. (In Spanish.)

Higher hematological values (hemoglobin, hematocrit, reticulocytes, sedimentation rate, leucocytes, eosinophils, basophils, and monocytes) were tabulated for normal men and women living in Arequipa, Peru (2,327 meters of altitude above sea level). Hematological variations were also noted in relation to sex. The results were compared with hematological values obtained in subjects at sea level and in other parts of the world.

Perceptual Physiology

279. Tactile Discrimination and Skin Temperature. K. A. Provins and R. Morton. *J. Appl. Physiol.*, 15 (1): 155-160, Jan. 1960.

The index finger of ten subjects was immersed in water at 0.75° C. for 40 minutes. Two-edge threshold discrimination was tested during cooling of the finger and subsequent spontaneous rewarming due to cold vasodilation. There was a marked deterioration of tactile discrimination at finger skin temperatures below about 8° C., although the curve showing the mean decrease of numbness with increasing skin temperature was displaced relative to the curve showing the mean increase of numbness with decreasing skin temperature. Tactile discrimination was also tested on five subjects at each of six water bath temperatures (2°, 4°, 6°, 8°, 15° and 30° C.). At each temperature the finger was immersed for 20 minutes and the finger circulation arrested after the first 5 minutes. There was little impairment of two-edge discrimination after 15-20 minutes immersion of

the finger at temperatures of 6° C. or higher. At 4° C. there was marked impairment, and at 2° C. all subjects experienced complete numbness at the test site. It is suggested that the possibly differential effect of cold on sensory nerve endings in human skin may permit impulse conduction until the block is almost complete, at which point the sudden impairment of tactile discrimination noted is precipitated. (Authors' abstract, modified.)

280. The Influence of Flicker on the Level of Consciousness. G. J. Puister. *Aero-medica acta* (Soesterberg, Netherlands), 6:169-172, 1958. (In English.)

It was attempted to measure objectively by means of a stipple test and EEG a lowering of the level of unconsciousness experienced by pilots as a result of light flashes generated by the revolving propeller while flying in the direction of the rising or setting sun. Sixteen student pilots performed four stipple tests without interrup-

tion. During the performance of the second and third stipple test, the test paper, its surroundings, and the subject's face were intermittently illuminated by a stroboscope using monochromatic yellow light at the rates of nine flashes per second and seventeen flashes per second, respectively. The flicker was not used in the first and the last test. In ten subjects, an EEG was taken before and during the test performance. All recordings were within normal limits. EEG's taken during the test performance were identical with the pre-test EEG. The Bourdon-Wiersma scores indicated that a lowering of consciousness caused by flicker as found elsewhere on the strength of the subjective symptoms could not be proven by the stipple test. It is concluded that intermittent photostimulation under these experimental conditions does not lower the level of consciousness.

- 281. Influence of Head Tilt, Body Tilt, and Practice on Reduction of Error in Perception of the Postural Vertical.** C. M. Solley. *J. Gen. Psychol.*, 62 (1): 69-74, Jan. 1960.

It was hypothesized that subjects improve with practice in their accuracy of perception of the postural vertical in complex test conditions. Four groups of six subjects each were studied. Two conditions of body tilt—either 30° to the right or 30° to the left—were studied as well as two conditions of head tilt—either 30° to the right or 30° to the left. A given subject was always tilted in one direction with one direction of head tilt. Each subject had to return himself to the point where he perceived himself as aligned with true vertical on each of 30 trials. It was found that there was a significant reduction of error in perception of the postural vertical with practice, that right and left head tilts produced significantly different results, that there was a significant interaction between head tilt and trials, and that there was a significant interaction between head tilt, body tilt, and trials.

- 282. Night Vision.** G. E. Jayle, A. G. Ourgaud, L. F. Baisinger, and W. J. Holmes. xiv + 408 p. Springfield, Illinois: Charles C Thomas, Publisher, 1959.

Pilot vision during night flying (including preadaptation, takeoff, flight and landing) is discussed within a comprehensive treatise on night vision (p. 346-355). The book also includes chapters on the general characteristics of night light, biochemical data, physiologic and pathologic variations of night vision and techniques for the examination of night vision.

- 283. The Assessment of Distances** (Het beoordelen van afstanden.) G. ten Doeschate and J. Kylstra. *Aeromedica acta* (Soesterberg, Netherlands), 6:93-140, 1958. (In Dutch.)

In reviewing various depth perception theories, the authors show that seeing in the third dimension is no simple physiologic process but the result of the combined action of both binocular and monocular factors: stereoscopic parallax, accommodation and convergence adjustment, as well as the monocular factors such as distribution of light and shadow, intersection, movement parallax, and linear perspective. These factors, individually and in combination with each other, guide the distance assessment on the part of a pilot, but occasionally lead to errors in judgment that may have fatal consequences. A pilot who cannot see the ground or the sea loses touch with reality, since a visual field of blue sky or of fog or complete darkness yields an indeterminate space, which is as good as no space at all. Only the ratios of relative distances between objects in his field of view will allow him to judge correctly the distance required for successful landing. Hereby the movement parallax plays an important part and its application is a matter of long experience and practice.

- 284. Vision in Empty Space** (Het zien in de ledige ruimte.) G. ten Doeschate. *Aeromedica acta* (Soesterberg, Netherlands), 6:9-68, 1958. (In Dutch.)

Lack of visual contrast in high-altitude flight has a profound influence on visual perception and acuity. In searching the cloudless sky, the difficulty of focussing is analogous to the sensation of disorientation experienced in total darkness. Tests carried out on persons of different ages using specially devised apparatus led to the following conclusions: 1. Some young persons

who were tested for visual accommodation in empty space could perceive on a limited scale. The dioptric value was between 0.25 and 1.75. 2. Three older persons were unable to perceive anything. 3. With some individuals, the same visual accommodation was found in a completely empty visual field (180°) as was in a field of only 20°. 4. Sitting near a window outside the peripheral sensitivity of the retina had no effect upon visual accommodation. 5. The presence of a weakly illuminated dashboard at the lower window-frame had no effect upon accommodation capacity. 6. With a few tested persons the same accommodation capacity was found at 1.2 lux as was at 500 lux. 7. Perception of finer details of an object in empty space is extremely improbable. 8. After longer observation of a colored but otherwise empty field, its color characteristic is lost and transformed into a visual grey.

285. The Appearance of Parallel Lines (Evenwijdige lijnen en haar verschijningswijze.) G. ten Doesschate. *Aeromedica acta* (Soesterberg, Netherlands), 6:81-91, 1958. (In Dutch.)

Problems related to the visual perception of parallel lines are analyzed, and a brief survey is presented of the so-called "parallel paradox" and its formulation throughout the history of philosophy and mathematics.

286. Contact Lenses Worn by a Jet Pilot (Contactglazen bij een straaljagervlieger.) E. De Vries and J. Hoogerheide. *Aeromedica acta* (Soesterberg, Netherlands), 4:141-153, 1958. (In Dutch, with English summary.)

Experiments were performed in a low-pressure chamber to determine whether a jet pilot wearing corneal contact lenses to correct a slight myopia developed while in service may engage in flights in which the cabin pressure is equivalent to an altitude of 7000 m. or above. During the experiments the eyes of the pilot were constantly observed through a corneal microscope and a slitlamp. Flash photographs of bubble formations behind the contact lenses and fluorescein stains are included. During rapid decompression from 6096 m. to 8229 m. (in ½ second), gas bubbles behind the contact lenses were noticed. During slow decom-

pression, the first gas bubbles were observed at 6000 m. During ascent to 10,000 m., the number and extent of the bubbles increased. At 7000 m., with numerous gas bubbles present, no impairment in visual acuity was found. No displacement of contact lenses in a forward or sideward direction was observed at any time. Fluorescein stains of corneal epithelium at ground level revealed impressions in the epithelium; however, they disappeared within twenty-four hours. No displacement of the lenses was observed during accelerations of 6 g or more. On this basis it is concluded that the use of contact lenses is permissible in individual pilots, and certain tentative requirements for wearing contact lenses in flight are proposed.

287. Finger Numbness After Acute Local Exposure to Cold. R. Morton and K. A. Provins. *J. Appl. Physiol.*, 15 (1): 149-154, Jan. 1960.

The index finger of twenty subjects was exposed to air at -22° C. and a wind speed of 300 feet/min. until the indicated skin temperature fell to -5° C. The finger was then returned to room temperature conditions (19° C.) and the subject tested on each of two tasks involving tactile discrimination (two-edge discrimination and reproduction of finger pressure) until the finger had fully recovered. The degree of impairment on both sensorimotor tasks at a given skin temperature varied appreciably from subject to subject, although most subjects showed little impairment above about 8° C. Suddenness of recovery of two-edge discrimination in those subjects experiencing a marked impairment of tactile discrimination with cold exposure was suggested by the L-shaped curve of the relationship between numbness index and skin temperature. The evidence suggests that while finger numbness as measured by Mackworth's V-test may indicate a corresponding impairment of performance in accuracy of pressure reproduction, testing subjects on either task at normal skin temperature will have little predictive value for their relative performance after cold exposure in the present situation. (Authors' abstract, modified.)

Aviation and Space Psychology

- 288. The Effects of Food Deprivation and Restricted Activity Upon Exploratory Behavior of the Rat.** R. M. Carr, J. E. Overall, R. K. White, and W. L. Brown. *J. Genetic Psychol.*, 95 (2) : 321-328, Dec. 1959.

Thirty-six male albino rats were divided into two groups, with one group being maintained on a twenty-three hour food deprivation schedule throughout the experiment. Each subject was "confined" preceding one experimental period, and "not confined" preceding the other. The subjects were placed in the Y-maze at the choice point and allowed to explore for ten minutes on two consecutive days. Records were made of the number of 12-inch units explored per minute and of the orderliness of exploration. The experimental results support these hypotheses: (a) a reduction in exploration over time, (b) a decrement in exploration due to an internal drive arising from restricted activity, (c) no difference in orderliness of exploration between either the deprived and undeprived or confined and not confined animals; and (d) a suggestion of a decrement in exploration due to the internal drive aroused by food deprivation. (Authors' summary, modified.)

- 289. Psychiatric Research in Space Medicine.** G. E. Ruff and E. Z. Levy. *Am. J. Psychiat.*, 115 (9) : 793-797, Mar. 1959.

Identification of psychological stresses in space flight is possible at present only by inference from analogous experiences. However, problems of existence in an artificial environment and crew selection may be investigated through studies on the effects of isolation, confinement, and sensory deprivation. Small groups of five subjects each were observed at the Aero Medical Laboratory under conditions of prolonged confinement (five days) to a compartment designed to minimize monotony and physical discomforts. Physiologic and psychologic tests were administered before, during, and after the confinement. General features noted include the appearance of regressive behavior

as shown by preoccupation with phallic, anal, and oral themes, and feelings of hostility towards fellow crew members. Growth toward a more mature, less rigid handling of certain conflict areas was seen in comparing the pre- and postexperimental test material. It was attributed to group support extended to the individual during regressive phases. Severe reactions were rare. A non-volunteer group showed less verbal preoccupation and hostility, though the overall behavior pattern was similar to the volunteers. Seven classes of variables to be considered in planning isolation and sensory deprivation research are discussed. Behavior in individual isolation experiments is characterized by a brief phase of anxiety, followed by mobilization of ego defenses in an attempt to structure the experimental situation into a replica of familiar reality, and finally by impulsive termination of the experiment when unconscious material threatens to emerge. A sound ego which provides an effective frame of reference for meaningful structuring of experience is considered the best qualification for an astronaut. Both meaning and variety in sensory input have to be provided by the environment to prevent disorganization of the perceptual and thinking processes.

- 290. Psychological Causes in Aircraft Accidents.** P. M. van Wulfften Palthe. *Aeromedical acta* (Soesterberg, Netherlands), 6:69-80, 1958. (In English.)

Human factors of a psychologic character operative in aviation accidents or near-accidents are discussed. Although lipothymia (emotional fainting) is not regarded a rare phenomena in the field of aviation medicine, it has not been implicated as a casual factor in a statistical evaluation of aircraft accidents. Partial sensory deprivation experienced in solo flight frequently produces the so-called "break-off" phenomenon. Subsequent psychologic examination has revealed light symptoms of psychasthenia which, coupled with impaired health or stress provoking factors, nearly always precedes this isolation syndrome. Since only anxiety-

prone individuals experiencing the break-off state constitute a hazard in flight, pre-testing with a simulated isolation test is suggested. All confusional states in flight are presumed to be variations of the sham death and hyperactivity responses to imminent perceived danger. Fatigue and hypoglycemia are conducive to loss of mental alertness combined with automatism. Hyperventilation may enhance anxiety. The emotional effects of light flashes have not yet been explored to the same extent as its epileptogenic influence. In aircraft accident investigations, particularly in propeller planes, the flicker influence should be considered, and where possible, the pilot's resistance to flicker investigated. Near-accommodation in an empty visual field culture-habituated in a large percentage of emmetropes may be an essential factor in collision accidents or give rise to perceptual illusions through projection, which may lead to errors of judgment.

- 291. Catechol Amine Excretion and Behavior During Sensory Deprivation.** J. Mendelson, P. Kubzansky, P. H. Leiderman, D. Wexler, C. DuToit, and P. Solomon. *A. M. A. Arch. Gen. Psychiat.*, 2 (2): 147-155, Feb. 1960.

The effects of sensory deprivation on urinary epinephrine and norepinephrine ex-

cretion were studied in ten male volunteers. The subjects were placed in a tank-type respirator with a constant and monotonous visual and auditory input until the subject terminated the isolation or it was terminated after thirty-six hours. Behavioral measurement made during the experiment included length of stay, mental experiences, motor activity, amount of verbalization, somatic references and judgment of passage of time. The combined group data revealed a rise in epinephrine and norepinephrine excretion during the experiment, with a fall toward control values during the post-experimental period. There was a wide individual variation in the endocrine response, five categories being differentiated. Two statistically significant relationships were found between the behavioral measures and changes in catechol amine excretion. The greater the change in epinephrine excretion under experimental stress the less error there is in time estimation. The greater the post-experimental fall in norepinephrine excretion, the fewer are the verbalizations and somatic references, and the smaller is the error in time estimate. The relevance of these findings to previous studies and the problems of relating biochemical indices to behavioral assessments are discussed. (Authors' summary, modified.)

Aviation and Space Flight Personnel

- 292. Psychiatric Evaluation of Candidates For Space Flight.** G. E. Ruff and E. Z. Levy. *Am. J. Psychiat.*, 116 (5): 385-391, Nov. 1959.

Procedures for selection and psychologic evaluation of the pilots for Project Mercury are described. Eligibility for the mission was restricted to a select group of test pilots, thirty-two of whom were chosen for the final phase of the selection program. In this phase the final medical and psychologic evaluation was made and the capacity for tolerating stress conditions expected in space flight was determined. The psychiatric evaluation included 30 hours of psychiatric

interviews; 25 psychologic tests assessing motivation, personality, intellectual functions, and special aptitudes; and observations of behavior in the following stress experiments: (1) pressure suit test in low-pressure chamber at 65,000 m. altitude, (2) three hours in the isolation room, (3) a complex behavior test, (4) acceleration at different g loads, (5) noise and vibration stresses, and (6) exposure to heat of 130° F. for two hours. No evidence of psychosis, clinically significant neurosis, or personality disorders was observed in any of the thirty-one candidates who passed through the complete series. They can be described as mature, well-integrated, highly adaptable,

action-oriented individuals with a high level of intellectual functioning, who had been successful in demanding missions in the past. Their stress tolerance levels were

among the highest. Motives for volunteering varied, but all seemed to be attracted by the constructive rather than the destructive aspects of the mission.

Operational and Human Engineering Aspects

- 293. Background to the Spacecrew Holding Facility.** J. E. Ward and J. G. Wells. *Astronautics*, 5 (2): 32-33, Feb. 1960.

The initial design objectives of a mobile, biomedical van complex for the selection and prelaunch holding of spacecrews include: (1) provision for an animal-colony holding facility embodying the principles of epi-

demiology and permitting detailed pre-flight and post-flight psychophysiologic measurements and experimental preparations; (2) provision for the preparation, modification, repair, instrumentation, and countdown of bioastronautic experiments, and (3) a rugged mobile system operating independently, and able to support any bioastronautic project.

Survival and Rescue

- 294. Hyperphagia and Gastric Hypertrophy in Rats Adapted to Intermittent Starvation.** E. Holečková and P. Fábry. *Brit. J. Nutrition* (London), 13 (3): 260-266, 1959.

Adult female rats adapted to intermittent starvation for 17 weeks demonstrated, with gradually increasing periods of fasting, a gradually increasing intake on the days of free access to food. In the last week of the experiment, the adapted animals ate on the average of 112 g of food in two 1-day portions, whereas non-starved rats ate on the average of 133 g of food in seven daily portions. The increased quantity of food eaten in one portion led to gastric hypertrophy. This condition was first apparent after six weeks of intermittent starvation but gradually disappeared after re-feeding. Gastric hypertrophy developed even though there was loss of body weight. No pathological changes in the gastric mucosa were found. (From the authors' summary.)

- 295. Space Feeding: Big \$\$ Market.** J. Baar. *Missiles and Rockets*, 5 (25): 28, 32, June 15, 1959.

At present the four main types of space food developed under Air Force contracts

are: semi-solid foods in tubes, bite-size solid foods, solid-food rods, and dehydrated foods. The containers may be utilized as food or eaten without ill effects. Although closed ecological systems may be disquieting psychologically, studies are underway to develop recycling systems for water recovery and food production. Various types of space food being developed in different industries are described, and the implications for commercial development are outlined.

- 296. Food: Space Age Problem.** *J. Agric. & Food Chem.*, 7 (9): 600-604, Sept. 1959.

Two possible solutions to the problem of feeding man in space are offered: (1) storage of food in miniaturized form, and (2) utilization of a closed ecological system for the continuous production of food during the space journey. Factors to be considered in the process of miniaturization (or dehydration) such as color, edibility, ease of eating, and stability, are briefly discussed. The use of algae as part of a closed ecological system for the production of food, exchange of oxygen and carbon dioxide, and the removal of waste is considered. Rate of generation and nutrient qualities are weighed against lack of variety

in the diet and the adverse psychologic impact of the astronaut's knowledge that he is eating his own waste. It is suggested

that both algae and miniaturized food will contribute to the food supply of the future astronaut.

Space Medicine and Biology

297. **DRML Scientists Probe Man's Space Limitations.** P. Brannan. *Canad. Aviation* (Toronto), 33 (3): 8-11, March 1960.

The work of the Defence Research Medical Laboratories at Downsview, Ontario, Canada, towards the solution of the problems of weightlessness and motion sickness in space travel is discussed. Muscular deterioration, circulatory changes, and problems of movement, as results of the weightless condition, are briefly considered. Experiments on motion sickness resulting from the utilization of angular acceleration to counteract weightlessness are also described.

298. **Medical Aspects of Ambient Radiations of Extraterrestrial Space.** P. A. Campbell. *J.A.M.A.*, 172 (7): 668-671, Feb. 13, 1960.

If man is to travel above and beyond the earth's atmosphere he will have to shield himself from radiations to which he is not ordinarily exposed. Three types of radiation here described are the primary cosmic radiation, the secondary cosmic radiation, and the two Van Allen bands of high-speed particles circulating about the earth's geomagnetic equator. Beginning at about 650 km. (400 miles) above the earth, radiation of the Van Allen type reaches intensities of 10 to 100 roentgens per hour, which would be fatal within thirty days to more than half of a number of human subjects exposed to it for two days. An important problem in space travel, therefore, is that of circumnavigating the two zones of Van Allen radiation or of devising shields within allowable weight limits. (Author's summary.)

299. **Medicine and Space Flight: Man in Capsule.** (Medizin und Raumfahrt: der Mensch in der Kapsel.) H. G. Clamann. *Flugkörper* (Wiesbaden), 2 (1): 16-18,

Jan. 1960. (In German, with English summary.)

In a lecture delivered at Düsseldorf, Germany, the author reviewed current and projected areas of investigation in the medical problems of space flight. The subjects discussed included acceleration tolerance, weightlessness, the use of pressure suits, hazards of Van Allen belt radiations, the food requirements and techniques for space flight feeding, methods of re-cycling water and of CO₂-O₂ exchange, isolation, and tolerance to high dry-heat temperatures.

300. **Bioengineering Problems in Early Manned Space Flight.** R. W. Lawton, B. J. Smith, and D. R. Ekberg. *Annals N. Y. Acad. Sci.*, 84 (2): 29-74, Feb. 26, 1960.

A selective review directed towards the solution of the engineering problems associated with the biologic, psychologic, and medical criteria of a short-term, 200-mile-altitude, manned orbital flight is presented. Topics considered are acceleration (launch, reentry, reentry at escape velocity, impact, weightlessness), noise and vibration, control of the gaseous environment (four-gas and three-gas systems, gas expansion, explosive decompression, rapid decompression), temperature control, metabolism, nutrition, biomedical monitoring (manned flight instrumentation, communication systems), human performance under weightlessness (factor analysis, task regime), and safety and reliability.

301. **Endogenous Rhythms of Body Temperature in Hibernating Bats.** M. Menaker. *Nature* (London), 184 (4694, Suppl. 16): 1251-1252, Oct. 1959.

Bats were removed from their nature site of hibernation and maintained at a temperature of approximately 6° C. They were then placed in a dark, moisture-controlled

chamber at a constant temperature of 8-10° C. Rectal temperature was recorded continuously. It was found that a rise in temperature occurred rhythmically at a period of about twenty-four hours, from a base temperature approximately equal to that of the chamber. In the case of bats collected in the autumn, when hibernation was not well established, the rise above the temperature of the chamber did not exceed 1.5 degrees. Experiments conducted after a longer period of hibernation, however, demonstrated a rise of at least 15° in some instances. In the latter case, temperature rises varied greatly, on some days not occurring at all. The periodicity of the rises was nevertheless unaffected by the degree of fluctuation.

302. Impact of Space Exploration on Biology and Medicine. C. T. Randt. *J.A.M.A.*, 172 (7): 663-665, Feb. 13, 1960.

The interest in space exploration has stimulated biologic and medical research on the tolerance and adaptability of the human organism to the stresses of acceleration, vibration, temperature, weightlessness, and isolation. It is expected that study of animals and man in actual or simulated space environments will also contribute to understanding of basic processes of consciousness, orientation, thinking, emotion, and motor coordination. The complexity and inter-dependence of problems anticipated in manned space flight call for an integrated approach by both the physical and biologic sciences.

303. Radiation and Life in Space. C. A. Tobias. In: Fenn, W. A., *Symposium on Life in Space*, 1242-1249. Federation Proceedings, 18 (4), Dec. 1959.

Radiation encountered in outer space, including ultraviolet rays, x-rays, primary cosmic rays (chiefly atomic nuclei), and secondaries (resulting from the breakup of primary particles in the earth's atmosphere) are described and discussed briefly in relation to their physiologic effect on man traveling in space. Some specifications for the path of a space rocket are enumerated.

Heavy primary components, cosmic ray variations due to solar flares, and magnetic storms are also considered. The necessity for the determination of the effects of radiation on man and for the development of adequate shielding devices is stressed.

General

304. Performance of Pilots and Students on a Complex Perceptual-Motor Task. D. S. Abbey and M. Humphries. *Perceptual and Motor Skills*, 10 (1): 27-30, Feb. 1960.

An experiment was conducted to determine the effect of prior training upon performance contrary to trained responses. A Toronto Complex Coordinator, in which matching of display positions was accomplished by movement of a control stick differing from the standard airplane stick in reversal of forward and backward movements (resultant vertical motion), was utilized to test the response differences between nine qualified RCAF pilots and ten male college students. The number of successful matches per minute, and the number of horizontal and vertical errors were recorded. Better scores were achieved by the pilots in each case. There was no apparent correlation between groups and direction of error. Since expected difference in pilot error between horizontal and vertical components failed to occur, it is suggested that habits of control stick manipulation are specific to the aircraft situation, and are not transferable to the experimental apparatus. The observed superiority of pilots to students may be related to their general motor skills ability or to their familiarity with stick control apparatus.

305. Progress Toward Space Flight. P. A. Campbell. In: Fenn, W. A., *Symposium on Life in Space*, p. 1255-1259. Federation Proceedings, 18 (4), Dec. 1959.

Manned space travel is seen as a logical development of the physiologic, psychologic, and sociologic attributes of man. Certain problems exist today which must be solved before the man/machine gap in space travel can be overcome. They include the physiologic aspects of altitude, speed, radiation,

weightlessness, reentry (heat and acceleration), and body maintenance. At present the man/machine lag is maintained through a preponderance of physical scientists, rather than biologic scientists, in space research. Developments in Project Mercury and the X-15 spacecraft are briefly discussed.

ceiving cortisone, cortisol, prednisone, 2-methyl-9-chlor-hydrocortisone and dexamethasone. Progesterone had a less protective action. An increased resistance to cold was observed in normal rats treated seven days previously with ACTH, prednisone, and ascorbic acid.

- 306. Effects of Flight Simulator Motion on Pilots' Performance of Tracking Tasks.** J. G. Douvillier, H. L. Turner, J. D. McLean and D. R. Heinle. National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif. Technical Note No. D-143, 34 p., Feb. 1960. Unclassified.

The effect of rolling and pitching motions of a flight simulator on pilots' performance of simulated tracking tasks has been investigated by comparing the air-to-air tracking performance of two pilots in flight, on a motionless flight simulator, and on a flight simulator free to roll and pitch. A drone display and a circle-dot display were used for two tracking problems: (1) a pure pursuit task and (2) a lead-collision task. It was concluded that, in flight the drone display offers no improvement in tracking accuracy over the conventional circle-dot display under the essentially static conditions of attacks against a non-maneuvering target. For pursuit attacks against a maneuvering target, the circle-dot display is appreciably superior in both average tracking error and in variability of tracking error. For flight simulator studies of cockpit displays it appears that a motionless simulator should not be used. (From the authors' conclusions.)

- 307. Action of Different Substances on the Resistance to Cold in Normal and Adrenalectomized Albino Rats.** [Abstract]. C. M. Garrido. *Acta physiol. latinoam.* (Buenos Aires), 9 (3): 233-234. (In English.)

Survival time of adrenalectomized rats exposed to intense cold was not modified by the administration of glucose, ascorbic acid, ACTH, somatropin, levo-thyroxine, adrenaline, DOCA, or 19-nor-methyltestosterone. Normal rats were not protected by glucose or somatropin administration. Survival time in intense cold was prolonged in rats re-

- 308. Coordination of Posture and Movements of Man in Conditions of Increased and Decreased Gravity** (Koorditatsiia pozq i dvizhenii cheloveka v usloviakh povyshennoi i ponizhennoi gravitatsii). V. C. Gurfinkel', P. K. Isakov, V. B. Malkin, and V. I. Popov. *Biulleten' eksperimental'noi biologii i meditsiny* (Moskva), 48 (11): 12-18, Nov. 1959. (In Russian, with English summary.)

The effect of rapidly alternating phases of increased and decreased gravitational force on motor coordination and posture was studied in seven human subjects. Experiments were conducted in the elevator of Moscow University, which permits changes in gravity ranging from 2 G to 0.3 G within two to three seconds. Positional changes of body and extremities and motor coordination were recorded graphically. Under these experimental conditions no significant disturbances were registered either in coordination of positioning of the body and limbs or in the adequacy of motor performance. The role of the visual analyzer in maintaining equilibrium does not increase significantly under conditions of subgravity, as shown by analysis of equilibrium reactions of subjects with their eyes closed or open. It is concluded that a 50 per cent increase or decrease in gravity does not materially affect the system which regulates posture and movement on the basis of proprioceptive afferentation. (From the authors' summary.)

- 309. Effect of Prolonged Cold Exposure on the Glycolytic Enzymes of Liver and Muscle.** J. P. Hannon and D. A. Vaughan. *Am. J. Physiol.*, 198 (2): 375-380, Feb. 1960.

Liver and muscle tissue from male Sprague-Dawley rats, exposed to $5 \pm 1^\circ \text{C}$. for three to four weeks, were assayed for the activities of selected glycolytic enzymes. When compared to control animals main-

tained at $25 \pm 1^\circ \text{C}$., the cold-exposed animals showed an increase in liver glucose-6-phosphatase, an increase in liver and muscle glucokinase, a decrease in glucose-6-phosphate, and 6-phosphogluconic dehydrogenase in both liver and muscle, and an increase in the rate of pyruvate formation from 3-phosphoglycerate in liver tissue. Assays of liver and muscle phosphoglucomutase, total liver and muscle phosphorylase and phosphorylase a and b in muscle failed to show any cold effect. The results indicate the cold-exposed rat has the enzyme capacities for: an increased utilization of free glucose, an increased glycogenolysis either to free glucose or pyruvate and an increased gluconeogenesis. They also indicate a decreased hexose monophosphate shunt activity. Little evidence could be found to indicate an epinephrine-induced activation of phosphorylase in the cold-exposed animals. (Authors' abstract.)

- 310. Behaviour in Controlling a Combination of Systems. II. Effects of Changes in the Velocity of Disturbances.** K. F. Jackson. *Ergonomics* (London), 2 (4): 363-366, Aug. 1959.

An experiment was performed to determine the effect of variation in the velocity of disturbance on the behavior of the operator in a continuous tracking task. The variably rotating pointers of four dials were controlled by sequential manipulation of four knobs, and the error, rate, and duration of manipulative movements were recorded. Results of the experiment indicated that the duration of interruptions, rate of working (in movements per trial), and the components of this rate (duration of control movements and change-over movements) were unaffected by changes in the velocity of rotation of the pointers. Errors occurring during interruptions and during control movements thus varied consistently with changes in the velocity of the disturbance. Although the variation in velocity of the pointer was not clearly perceived by the subjects, and thus no compensatory acceleration of the rate of performance was effected, this variation did produce changes in the amplitude and speed of control movements.

- 311. Temperature Sensation [Abstract].** E. Hendler and J. D. Hardy. *Mechanical Eng.*, 81 (8): 69-70, Aug. 1959. Full paper issued as "Temporal Aspects of Temperature Sensation," ASME Paper No. 58-A-220.

Seated subjects were placed in a neutral environment so that the selected forehead site could be heated by a far infrared source, or cooled by blocking exposure to this source at the same time that small temperature changes, of the order of 0.005°C ., were recorded continuously. Forty-six per cent of the total number of stimuli were increasing and 46 per cent were decreasing rates of change in skin temperature; the remaining 8 per cent involved no change in skin temperature. At frequent intervals (usually every ten seconds) the subjects were requested to report the temperature sensation experienced from the exposed forehead skin. Examination of the continuous skin-temperature records obtained show that neither the absolute skin-temperature level nor the change in skin temperature could be correlated with sensation reports.

- 312. The Effect of the Relative Position of Control and Display upon their Direction-of-Motion Relationship.** N. E. Loveless. *Ergonomics* (London), 2 (4): 381-385, Aug. 1959.

The effect upon performance of the direction-of-motion relationship between a control and a display is shown to depend upon certain other features of the layout. When a rotary control knob is used in conjunction with a linear indicator, a clockwise movement of the control is expected to move the pointer upwards or to the right. This expectation is, however, weaker when the center of rotation of the control is situated on the line of movement of the display than when the control is situated to the side of the line, so that the pointer moves in the same direction as the nearest part of the knob. The orientation of the display and the position of the control have no effect apart from this relationship between them. (Author's abstract.)

- 313. Effect of Sleep Deprivation on Plasma 17-Hydroxycorticosteroids.** B. K. Murawski and J. Crabbé. *J. Appl. Physiol.*, 15 (2): 280-282, Mar. 1960.

Paid volunteers (18 male college students) were deprived of sleep for one night on two separate occasions when alone. On a third occasion they were asked to stay up all night in groups of four. Plasma concentrations of 17-hydroxycorticosteroids at 8 A.M. following the nights without sleep were 4 to 5 micrograms lower than control values. The noon values after sleep deprivation in a solitary setting were not significantly different from the corresponding control values. When subjects stayed up with three other people, the noon values tended to be higher. Urinary 17-hydroxycorticosteroid level showed a decrease following the nights without sleep, but this decrease did not reach statistical significance. (From the authors' abstract.)

314. The Effects of Task Complexity and Time Pressure upon Team Productivity. P. N. Pepinsky, H. B. Pepinsky, and W. B. Pavlik. *J. Appl. Psychol.*, 44 (1): 34-38, Feb. 1960.

An experiment was designed to test the effects of the complexity of repetitive group tasks and of varied conditions of time pressure upon the output of work teams. Twenty-four three-man teams each performed two practiced assembly tasks of the same type, one relatively simple, and the other relatively complex. Time pressure was established at three levels by varying the frequency of interspersed oral signals, which announced the time remaining in a given work session. Team productivity was defined as an adjusted total of the number of operations performed on each task. Scores obtained on the more complex and therefore more interesting task were consistently higher than those on the simpler task. Thus, the positive motivational effect of task complexity on the maintenance of interest in the performance of repetitive operations was demonstrated. Scores were also higher from the second session than from the first, regardless of task. A gain in productivity irrespective of these factors was noted, however, with intensification of time pressure. While an increase in time pressure from low to medium intensity caused a gain in productivity, a decrement occurred when pressure was increased to a higher level. (Authors' summary, modified.)

315. X-Irradiation and Acceleration Stress. J. W. Taylor. Naval Air Development Center, Aviation Medical Acceleration Lab., Johnsville, Pa. Report No. NADC-MA-6003, Mar. 1, 1960. i+6 p. (Task MR005.15-0002.14, Report No. 1). Unclassified.

A study was carried out to determine if a correlation existed between the stress due to x-irradiation and the stress due to acceleration. Sprague-Dawley rats were exposed to an acute dose of $600 \text{ r} \pm 20$ per cent x-irradiation and then centrifuged at 20 G for seven minutes. The data resulting from this procedure were then compared with data for two control groups, one centrifuged and one irradiated. There appeared to be no significant correlation between irradiation stress and acceleration stress at the experimental levels used in the study. Irradiation at this acute dose apparently has no significant effect upon the animals' ability to withstand acceleration. Deaths occurred after centrifugation of irradiated animals at about the same rate as for irradiated controls, indicating that acceleration has little effect upon the animals' ability to withstand irradiation. It is possible, however, that higher doses might affect tolerance to acceleration. (From the author's summary and conclusions.)

316. Histologic Alterations in Muscles of Guinea Pigs During Chronic Hypoxia. E. Valdivia, M. Watson, and C. M. S. Dass. *A.M.A. Arch. Pathol.*, 69 (2): 87-96, Feb. 1960.

Alterations in the mitochondria and in the number of capillaries of muscle sections from adult male guinea pigs exposed to prolonged periods of simulated high altitude were studied. The animals were exposed to a simulated altitude of 16,500 feet at 20° to 25° C. for periods of (1) up to three months, (2) from five to ten months with brief relief every 48 hours, or (3) continuously for eight or ten months. Tissue sections from thigh muscles were studied by microscopic and electron microscopic techniques. Sections from animals exposed to altitude for up to three months showed only a slight increase in size of the mitochondria. Sections from the groups exposed for five months or more, however, showed significant alterations in the mitochondria

pattern. The number of peripheral and perinuclear mitochondria was increased. Perinuclear clumps were more distinct, and the association of perinuclear mitochondria, muscle fiber nucleus, and red blood cell-filled capillaries was more evident. Giant mitochondria were frequently seen. The number of red blood cell-filled capillaries surrounding the muscle fibers was increased. Electron microscopic examinations indicated a close packing of cristae mitochondriales to produce greater mitochondrial density. The changes observed may correspond with a greater efficiency of the respiratory enzymes and of the utilization of oxygen.

317. **Project Mia (Mouse-In-Able), Experiments on Physiologic Response to Spaceflight.** F. L. Van Der Wal and W. D. Young. *ARS Jour.*, 29 (10, Part 1): 716-720, Oct. 1959.

The survival equipment (cradle assembly, oxygen supply, ventilation system, air purification system), the restraint harness, and the telemetry system for the two experimental mice in Project Able are described. Because of the limited telemetry capacity available, measurement of the heart rate was selected as the one physiologic parameter which would be most informative. Interpretations and comparisons were made of the physiologic responses of the animals (one male, one female) by correlating heart beat records with various physical parameters (lift-off, acceleration, altitude, zero gravity, deceleration, return to earth's atmosphere) of the flight environment. Although the nose cones carrying the mice were not retrieved, evidence indicated that both survived re-entry into the earth's atmosphere.

318. **Physiological Aspects of Hypergravic and Hypogravic States: Application to Space Flight.** J. E. Ward. *J.A.M.A.*, 172 (7): 665-668, Feb. 13, 1960.

The extremes in gravitational forces which will confront man in space flight range from above 40 G during deceleration to zero gravity during flight in orbit. It has been shown experimentally that the human or-

ganism tolerates up to 50 G applied at 500 G/second for less than 0.2 second. A more rapid rate of application reduces the tolerance limit. Tolerance during the powered flight phase with acceleration forces of 4 to 10 G, will be raised by proper positioning. The functional problems of the human body subjected to periods of zero gravity concern neurologic mechanisms, spatial orientation, motion sickness, cardiovascular and gastrointestinal functions, waste elimination, psychomotor performance, and diurnal rhythms. There is some indication that acclimatization to weightlessness may result in lower positive G tolerance upon re-entry. Collection of additional psychophysiology data will be one of the more important objectives of manned space flight.

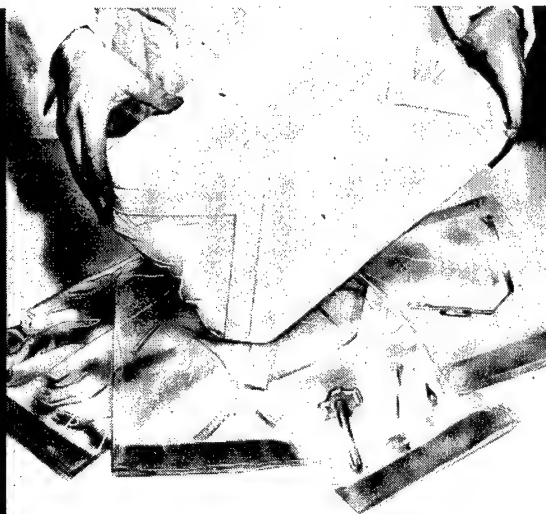
319. **Rest Pauses in a Task Affected by Lack of Sleep.** R. T. Wilkinson. *Ergonomics* (London), 2 (4): 373-380, Aug. 1959.

The Five Choice Test, in which the tapping of lighted bulbs arranged on a board lights other bulbs in a serial fashion, was utilized to test the effects of one night's loss of sleep on performance. The number of correct taps, number of errors, and occurrence of gaps (any pause beyond 1.5 seconds) were measured in control and sleepless subjects. In one test, performance was continuous for twenty-five minutes, while in a second series a thirty second break was allowed after each five minutes of performance. The following results were obtained: an increasing number of gaps and corrects occurred throughout the thirty minutes of performance in sleepless subjects; with thirty second breaks, performance was only slightly better among both groups; the effect of breaks on the occurrence of corrects was slightly greater than on the occurrence of gaps; no interaction between lack of sleep and continuous performance was noted. The lack of significant response to thirty second breaks, both in sleepless and normal subjects, is in contrast to previous findings concerning the beneficial effect of five minute breaks, and indicates the existence of a crucial time point somewhere between the two points tested.

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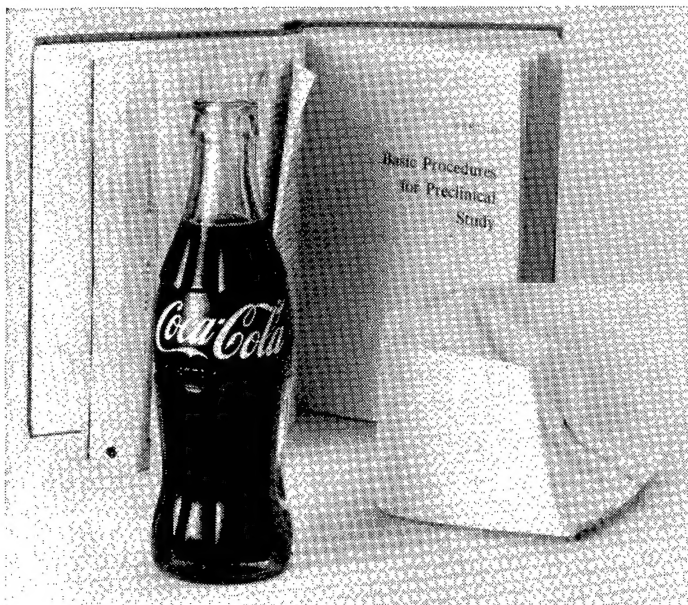
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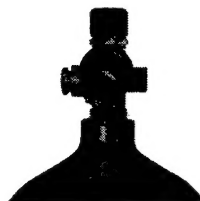
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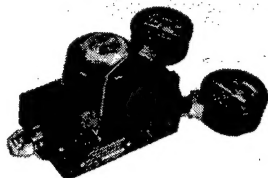
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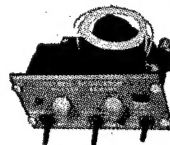
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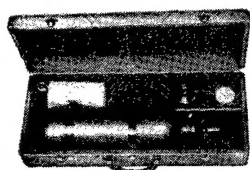
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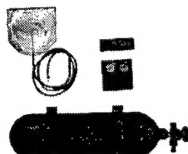
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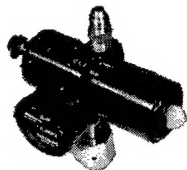
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